A PHENOMENOLOGICAL REVIEW OF THE EFFECTS OF WRITING DURING MATHEMATICAL PROBLEM-SOLVING ON COGNITIVE REGULATORY SKILLS IN GIFTED AND HIGH-ACHIEIVING STUDENTS

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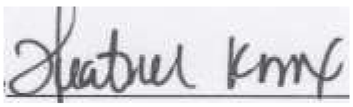

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Abstract

The purpose of this phenomenological study was to examine the lived experiences of 12 gifted and high-achieving learners with the use of writing during the mathematical problem-solving process and its impact on their cognitive regulatory skills. The results of this study may help to provide educators with insight on ways to increase academic achievement and growth for gifted and high-achieving learners.

A qualitative analysis of in-depth interviews, classroom observations, and student work samples revealed five themes that helped depict the experiences of the participants when writing was implemented into the mathematical problem-solving process: (1) achieving accuracy; (2) established self-regulating strategies; (3) consideration and awareness; (4) self-efficacy; and (5) conceptual understanding. Findings of this study revealed that writing during mathematical problem-solving had a positive impact on the use and development of certain cognitive regulatory skills. The results also showed that writing served to increase mathematical conceptual understanding. Insights from this study support the conjecture that writing during the problem-solving process for gifted and high-achieving learners could serve as a strategy to increase both their academic achievement and growth.

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Dedication

This study is dedicated to the two most important things in my life: God and my husband, Jimmy. Without my faith in God and the encouragement and support of my husband, I would not have made it through this journey. Both have shown me the true meaning of unconditional love and have been my solid rock through many difficult times. I cannot fathom the incomprehensible love that God has shown for me and will dedicate my life to serving Him and showing others the love and beauty of the gift of Jesus Christ and the salvation that comes from believing in Him. To my Jimmy, you have shown me the true meaning of love on earth. I am so grateful to you for being our spiritual leader, our protector, and our provider. Thank you for being you and loving me in a way that surpasses all of my dreams.

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CHAPTER ONE: Introduction

Accountability for academic achievement for all students became a significant aspect of public education with the reauthorization of the *No Child Left Behind Act* (NCLB) (Johnsen, 2014). This act required students, teachers, schools, and districts to be held accountable for ensuring systematic growth for every student during each school year rather than focusing merely on proficiency (Clark, 2013; Johnsen, 2014). Since that time, schools and school districts have analyzed student achievement and growth for a variety of subgroups to determine if appropriate academic achievement and growth has been made. In many states, this analysis revealed gifted and high-achieving students either exhibited minimal gains or outright declines in academic growth (Camilli, 2008; Johnsen 2014; Loveless, Parkas & Duffett, 2008; Sanders & Horn, 1998; Spielhagen, 2012). For years the standardized academic achievement score was the only measure used to determine student academic success and since many gifted and high-achieving students performed on the upper end of these norm-based assessments, it appeared that these students were achieving at an acceptable rate (Camilli, 2008; Clark, 2013; Johnsen, 2014; Loveless et al., 2008). Yet, when academic growth was introduced as an additional measure of academic accountability, it seems the gifted and high-achieving students were the ones being left behind (Loveless et al., 2008; Spielhagen, 2012). This left many school systems and teachers in a conundrum to find best practices that would successfully increase academic growth for gifted and high-achieving students.

Studies show that further development of metacognitive skills can positively impact academic achievement and academic growth (Chekwa, McFadden, Divine, & Dorius, 2014; Cross & Paris, 1988; Özcan & Erktin, 2015; Pokay & Blumenfield, 1990). Gifted and high-achieving learners tend to have metacognitive abilities that are more advanced than that of their peers with average IQs particularly in the area of cognitive knowledge (Alexander & Schwanenflugel, 1996; Carr, Alexander, & Schwanenflugel, 1996; Lawson & Chinnappan, 1994; Plucker, 2015; Schraw & Graham, 1997; Swanson, 1992; Yildiz, Baltaci, & Güven, 2011). However, all students, gifted and high-achieving students included, have difficulty with cognitive regulation (Carr et al., 1996; Jacobs & Paris, 1987; Pintrich, 2002). Writing is a process that can help students develop their cognitive and metacognitive skills (Card, 1998; National Council of Teachers of Mathematics, 2000). This study will research the cognitive regulatory experiences of gifted and high-achieving students when writing during the mathematical problem-solving process to determine if writing could be a way to help gifted and high-achieving students develop improve cognitive regulation.

Background of the Study

Incorporating research-based principles into instruction can help students learn better (Vosniadou, 2001). Researchers assert that the development of cognitive and metacognitive skills is one of the most important components of the learning process (Flavell, 1979; Perkins, 1995). Students should be taught the art of self-reflection to aid in the construction of their knowledge and the advancement of their cognitive abilities (Vygotsky, 1978). Although this process of thinking about one's own thinking has been discussed in association with learning for many years, it was not until the 1970s that Flavell (1979) coined the term metacognition to describe it (Hammond, Austin, Orcutt, & Russo, 2001).

Metacognition

The process of metacognitive thought is controlled in the reflective learning system (Given, 2002). It is this learning system that manages reflection as well as all other functions of the brain. The reflection process is one that requires nurturing (Perkins, 1995). Teaching students the appropriate way to develop this self-reflective process is a vital need in education (Given, 2002).

Metacognition is comprised of three main components: cognitive knowledge, cognitive experiences, and cognitive regulation (Brown & DeLoache, 1978; Cross & Paris, 1988; Flavell, 1979; Schraw, Crippen, & Hartley, 2006; Veenman, Van Hout-Wolters, & Afflerback, 2006; Vrugt & Oort, 2008). Cognitive knowledge is stored knowledge one uses to complete a task or achieve a goal (Cao & Netfield, 2007; Flavell, 1979). The awareness of one's emotions throughout their thinking process is known as cognitive experiences (Flavell, 1979). Cognitive regulation involves the managing of one's cognitive tasks (Cross & Paris, 1988; Paris, Lipson, & Wixson, 1983).

Researchers suggest that students should be directly instructed on ways to develop their metacognitive skills because of the many direct benefits that come with metacognitive development (Flavell, 1979). The development of metacognitive skills can help students become more aware of what they do and do not know, organize and enhance their thinking, become more independent during the problem-solving process, and increase their academic achievement (Ashman, Wright, & Conway, 1994; Cao & Netfield, 2007; Cross & Paris, 1988; Schraw & Graham, 1997; Stan, 2012). The development of these skills, in particularly the skill of cognitive regulation, can help students engage in more intelligent behavior (Perkins, 1995). To be effective, metacognitive skills should be taught in conjunction with cognitive tasks to allow students to see how they can be used directly during the thinking process (Cross & Paris, 1988; Paris et al., 1983; Perkins, 1995).

Research-based practices should be followed when providing instruction to students on the skill of metacognition. Teachers should model the appropriate use of reflective thought by employing effective questioning techniques on assessing, critiquing, and managing one's own thinking (Given, 2002). Teachers should also inform students of the purpose of metacognitive development, embed metacognitive instruction into content area instruction, and use prolonged and consistent instruction on skills that will increase their metacognitive development (Veenman et al., 2006).

Gifted and High-Achieving Learners

Gifted learners. Gifted learners are students who perform extraordinarily in one or more areas and have been tested by a person trained in the identification of gifted children (Kaufman, 1976). These students tend to learn quickly and at an earlier age, retain information for longer periods of time, and can handle situations that require complex thinking (Winebrenner, 2001). However, gifted students are an at-risk group, and it is up to teachers to ensure their academic growth and development (Clark, 2013; Winebrenner, 2001). In fact, many gifted learners do not meet their potential in the classroom because their skills have not been developed appropriately (Clark, 2013).

Typically, gifted learners have a higher level of metacognitive skill development than non-gifted learners, and these skills develop at an earlier age (Alexander & Schwanenflugel, 1996; Schraw & Graham, 1997; Swanson, 1992). Yet, gifted learners still struggle with the appropriate application of skills related to cognitive regulation (Carr et al., 1996; Jacobs & Paris, 1987; Pintrich, 2002). When direct instruction on metacognitive development is provided to gifted learners, their problem-solving and metacognitive skills can increase (Schraw & Graham, 1997; Tan & Garces-Bascal, 2013; Wilkins, Wilkins, & Oliver, 2006). This metacognitive development can lead the thinking of gifted learners to new heights (Schraw & Graham, 1997).

High-achieving learners. High-achieving learners are students who tend to make good grades and accomplish much (Clark, 2013). Teachers often recognize gifted students as high-achievers because of their achievement. However, gifted students are typically more diverse than high-achievers. Although there are is no certain difference between gifted and high-achieving, gifted students usually perform better in higher level skills such as generalizing, thinking abstractly, and synthesizing. High-achieving learners are often self-focused, goal driven, committed, and demanding (Jones & Spooner, 2006). They are also sponges for new information and perform better with skills related to knowledge and comprehension (Clark, 2013; Jones & Spooner, 2006). Interestingly enough, some high-achievers can reach giftedness by being provided with more opportunities for growth (Clark, 2013).

High-achieving learners have metacognitive abilities that exceed that of lower-achieving learners (Doganay & Demir, 2011; Sun, 2013; Vanderstoep, Pintrich, & Fagerlin, 1996). They employ the use of cognitive knowledge and cognitive regulation skills more frequently and more accurately (Arslan & Akin, 2014; Lawson & Chinnapan, 1994). However, direct instruction of metacognitive skills can still benefit high-achieving students academically (Darling-Hammond et al., 2003; Given, 2002; Lioe, Ho, & Hedberg, 2005; Mevarech & Kramarski, 1997; Kramarski, Mevarech, & Arami, 2002). Specifically, high-achieving learners tend to struggle with the cognitive regulatory skill of monitoring and regulating when it comes to taking skills they know and applying it in different situations (Anderson, 1990; Bandura, 1993; Frye, 1989; Kramarski, Mevarech, & Lieberma, 2001).

Metacognition and Mathematics

Lester (1994) suggests that metacognition is the foundation of successful problem-solving and development of metacognitive skills can improve students' mathematical performance (Garofalo & Lester, 1985; Pugalee, 2001; Young, 2010). Cognitive knowledge development about mathematical strategies can help students improve their role as mathematicians in the classroom (Carr et al., 1996; Garofalo & Lester, 1985). The development of cognitive regulatory skills such as planning, managing, and evaluating can increase academic achievement (Charles & Lester, 1984).

Writing and Metacognitive Development

The process of writing can benefit students by increasing metacognitive skills and acquiring new knowledge (Card, 1998; National Council of Teachers of Mathematics, 2000). Writing can help students differentiate between what they know and what they do not know, describe their thinking, recall learned strategies, and ask questions (Knipper & Duggan, 2006). Not only can the process of writing help to develop metacognitive skills, it can also further communication skills, reasoning skills, and help students make connections (Card, 1998; Schudmak, 2014).

Writing and Mathematics

Writing can benefit mathematics achievement in many ways. Integrating writing into math can help students make meaning of mathematics and increase their ability to reason (Mills, O'Keefe, & Whitin, 1996; Polya, 1957). It also encourages discovery of new ideas and allows the thought process of students to be made visible (Whitin & Whitin, 2000). When implemented effectively, writing in math can develop a community of mathematical learners that emphasizes the process of mathematics, promotes mathematical communication, and recognizes that the thinking of others can help us grow mathematically.

Integrating reading, speaking, and writing into the mathematics classroom helps students further their metacognitive thinking and deepen their mathematical conceptual understanding by providing students with an opportunity to communicate mathematically (National Council of Teachers of Mathematics, 2000). Specifically, when writing is incorporated into mathematics instruction, students learn to become mathematical authors who use mathematical terminology, make connections to prior learning, learn and experience different cognitive strategies, record their own mathematical discoveries, and revise and reflect their mathematical thinking (Mills et al., 1996, National Council of Teachers of Mathematics, 2000). Writing allows the thinking of students to be made visible to others (Whitin & Whitin, 2000). By providing students with the opportunity to share their mathematical thinking with other students, teachers transform their classrooms into collaborative learning environments where mathematical communication is highlighted, and the focus of mathematics instruction is on the process rather than the solution.

Writing in mathematics can also serve as an effective tool for mathematical growth. Words are a vital component of reasoning (Polya, 1957). Using words in writing can help us direct our thinking through the processes of approaching a problem, solving a problem, and evaluating a solution (Whitin & Whitin, 2000). To gain the most out of mathematical writing, teachers should build in time for reflection during the thinking process, develop a classroom environment where mistakes are seen as opportunities for learning, and differentiate their teaching based upon the thinking of their students. Incorporating these best practices along with writing helps provide students with an environment where they can construct, grow, and strengthen their mathematical understanding.

Writing During the Mathematical Problem-Solving Process

Using writing throughout the mathematical problem-solving process can help develop metacognitive skills (Williams, 2003). Cognitive knowledge, reflection, and evaluation are employed when students write during the problem-solving process (McCormick, 2010; Schudmak, 2014; Van der Stel, Veenman, Deelen, & Haenen, 2009). Direct instruction is necessary for students to learn to appropriately use writing throughout the problem-solving process (Kuzle, 2013). Researchers such as Polya (1957), Schoenfeld (1982), and Pugalee (2001) have developed strategies and researched the effects of implementing these strategies during the mathematical problem-solving process. These strategies include the phases of analysis, design, exploration, implementation, and verification (Polya, 1957; Pugalee, 2001; Schoenfeld, 1982).

Writing in Mathematics for Gifted and High-Achieving Learners

Implementing writing in mathematics can help develop a metacognitive mindset in gifted and high-achieving learners which aids in mathematical development (Garofalo & Lester, 1985; Pugalee, 2001; Kramarski & Mevarech 2003; Young, 2010). However, this process should be differentiated for gifted learners because of their cognitive abilities (Schraw & Graham, 1997; Wiesman, 2013; Wilkins et al., 2006; Zimmerman, 1986). Teachers should work in developing writing strategies that increase their strengths and address their needs (Wilkins et al., 2006).

Statement of the Problem

What can educators do to advance academic achievement and academic growth in gifted and high-achieving learners? The researcher began exploring this topic through a review of the literature involving components of effective learning. The researcher discovered that one of the critical ingredients to learning, which is also the one in most need of attention, was metacognitive development (Perkins, 1995; Vosniadou, 2001). The researcher then researched metacognitive development in relation to gifted and high-achieving learners and found that although gifted and high-achieving learners typically perform well in cognitive knowledge functioning, they still have room for growth related to cognitive regulation skills such as planning, monitoring or regulating, and evaluating (Ablard & Lipschultz, 1998; Alexander & Schwanenflugel, 1996; Carr et al., 1996; Schraw & Graham, 1997; Jaušovec, 1994; Yildiz, Baltaci & Güven, 2011). Even though studies have identified cognitive regulation as an area of develop for gifted and high-achieving learners, many of these studies suggested further research was necessary in order to determine what strategies are effective in developing these cognitive regulatory skills in gifted and high-achieving learners (Ablard & Lipschultz, 1998; Alexander & Schwanenflugel, 1996; Carr et al., 1996; Yildiz et al., 2011).

In researching strategies to develop metacognitive skills in gifted and high-achieving learners, several studies were examined on the development of metacognitive skills. These studies either addressed metacognitive development in general or focused on the cognitive knowledge aspect of metacognitive development along (Ablard & Lipschultz, 1998; Chekwa et al., 2014; Cross & Paris, 1988; Dogany & Demir, 2011; Lawson & Chinnappan, 1994; Özcan & Erktin, 2015; Pokay & Blumenfeld, 1990; Carr et al., 1994). Yet, there remains a gap in the knowledge related to effective strategies that advance cognitive regulatory skills in gifted and high-achieving learners.

When researching strategies used in metacognitive development, writing to learn came to the forefront (Knipper & Duggan, 2006). When writing is integrated into the content area, particularly in mathematics, cognitive and metacognitive development can occur (Card, 1998;

National Council of Teachers of Mathematics, 2000). Research revealed that writing in mathematics promotes many of the skills directly related to metacognitive development, including cognitive regulatory skills such as planning, monitoring, and evaluating (McCormick, 2010; Polya, 1957; Whitin & Whitin, 2006). Thus, leaving the researcher questioning how the implementation of writing effects the cognitive regulatory experiences in gifted and high-achieving learners.

Purpose of the Study

Since cognitive regulation is a complex function of the mind, determining how writing effects this function in gifted and high-achieving learners requires a more descriptive rather than numeric research approach. Qualitative research methods are used when a problem exists that warrants a thorough, multifaceted understanding of the issue (Creswell, 2007; Marshall & Rossman, 2011). The purpose of this qualitative research is to study how the implementation of writing during the mathematical problem-solving process effects the cognitive regulatory experiences of fifth and sixth grade gifted and high-achieving learners in a Southeastern suburban elementary school. Participants were selected using purposeful, criterion sampling which requires each participant to experience the same phenomenon (Creswell, 2007). A hermeneutic phenomenological approach guided the direction of this study. Hermeneutic phenomenology investigates the lived experiences of individuals during the implementation of a particular phenomenon to provide interpretation to its meaning (Creswell, 2007; Marshall & Rossman, 2011; van Manen, 1990).

Research Questions

Teachers have the responsibility to ensure all students, gifted and high-achieving students included, growth academically and learn new content every day (Loveless et al., 2008;

Winebrenner, 2001). Gifted and high-achieving students have been identified as an at-risk group with respect to academic achievement and growth (Camilli, 2008; Johnsen 2014; Loveless et al., 2008; Plucker, 2015; Sanders & Horn, 1998; Spielhagen, 2012). Thus, it is the responsibility of educators to search for effective strategies to aid in the academic growth of gifted learners. One area in which gifted and high-achieving learners could improve upon relates to the further development of cognitive regulation skills (Ablard & Lipschultz, 1998; Alexander & Schwanenflugel, 1996; Bandura, 1993; Carr et al., 1996; Kramarski, Mevarech, & Lieberman, 2001; Yildiz et al., 2011). Implementing writing during the mathematical problem-solving process has positively impacted metacognitive development in students (Özcan & Erktin, 2015; Pugalee, 2001).

This study seeks to understand the interaction between gifted learners and writing, particularly when used in mathematical problem-solving. Creswell (2007) recommends the use of central research questions in qualitative research to help determine and predict the approach necessary in the study. For the purpose of this study, the following research questions assist in the developing an outline of the research and guiding the research methodology:

1. How does implementing writing in the mathematical problem-solving process affect the cognitive regulatory experiences of gifted and high-achieving learners?
2. How does implementing writing in the mathematical problem-solving process affect mathematical conceptual understanding of gifted and high-achieving learners?

Rationale for the Study

The researcher is interested in investigating the impact of writing on the cognitive regulatory experiences of gifted and high-achieving learners during the mathematical problem-solving process. This study has implications on researchers, educators, gifted, and high-achieving learners. Research has not yet identified effective strategies in the development of cognitive regulatory skills in gifted and high-achieving learners. Examining the data in this phenomenological study can help to provide a conjecture for future research which could have more generalized application. These findings could also help educators develop curriculum to better address the academic needs of gifted and high-achieving learners. Research shows cognitive regulation is an area in which gifted and high-achieving learners could improve (Ablard & Lipschultz, 1998; Alexander & Schwanenflugel, 1996; Bandura, 1993; Carr et al., 1996; Kramarski et al., 2001; Yildiz et al., 2011). Determining how writing impacts the cognitive regulatory functions of gifted and high-achieving learners can provide insight on effective strategies to improve cognitive regulation, as well as, helping educators better understand misconceptions in the minds of gifted and high-achieving learners.

The Researcher

Since the researcher began her career as an educator, her professional passion revolved around three things: mathematics, writing, and the advancement of gifted learners. In her previous career as a tax accountant, the researcher understands the importance of deep conceptual understanding of mathematical concepts and see the significance academic achievement in mathematics can have on one's future. As a mathematics educator, the researcher seeks to discover research-based strategies to implement into their classroom which will help provide their students with mathematical understanding, achievement, and growth. The researcher stresses to her students the importance gaining full understanding of mathematical concepts as one learns them due to the foundational nature of mathematics. When a student does not fully grasp a concept or their conceptual understanding is flawed, its impact may not become visible until years later. Therefore, the researcher strives to build a mathematical community within her classroom where everyone shares their thinking and their discoveries and uses their mistakes as opportunities to learn.

It was not until graduate school that the researcher's passion for writing emerged. Working as a graduate assistant to a writing professor helped the researcher to see the benefit of using writing as a strategy in the content area to help deepen cognitive understanding. After graduating from graduate school, the researcher worked closely with our local section of the National Writing Project and became somewhat of an expert on writing in mathematics. In her research and experience, the researcher realized the impact writing can have on one's thinking process and their cognitive understanding. It was not until the researcher began researching the topic of this dissertation that she recognized the benefits of writing on metacognitive development.

Growing up as an identified gifted child was the researcher's initial reason gifted and high-achieving education became a passion. However, in her student teaching experience, the researcher had the opportunity to work in a magnet school within the school district. This experience propelled their desire to work with gifted and high-achieving students to a new level. It was inspiring to the researcher to see the shift in gifted and high-achieving education since she was a child and wanted to further her knowledge to advance the education of gifted and high-achieving learners to an even higher level. Recently, her school district began the process of providing the necessary gifted training to selected teachers within the district in order to gain their gifted endorsement. The researcher had the opportunity to attend this training and now serves as the gifted cluster teacher for her grade level.

It is the researcher's hope that this study will help find a way to further improve gifted and high-achieving education and better understand the effects writing has on the cognitive regulation process as well as mathematical conceptual understanding.

Definition of Terms

Cluster group. Inclusion model that allows gifted learners to receive services daily during classroom instruction (Brulles, Saunders, & Cohn, 2010).

Cognitive regulation. Management of cognitive tasks including planning, monitoring, and evaluating (Cross & Paris, 1988; Paris et al., 1983).

Gifted learner. Child whose academic abilities are adversely affected by their intelligence (Tennessee Department of Education, n.d.).

High-achieving learner. Child who performs in the top 25% of their class based on benchmark assessments and classroom performance.

Mathematical conceptual understanding. A student's ability to reason through mathematical tasks using concepts, connections, and representations which can be demonstrated through the generation of examples, the use of models or diagrams, the identification of principles, the application of definitions, and the recognition and interpretations of signs and symbols (NAEP, 2003; National Council of Teachers of Mathematics, 2000).

Metacognitive abilities. A student's ability to reflect on their own thinking, particularly involving cognitive knowledge and cognitive regulation (Cao & Netfield, 2007; Flavell, 1979).

Problem-solving process. A four-step process to solve mathematical problems involving understanding the problem, devising a plan, carrying out the plan, and evaluating the work (Polya, 1945).

Summary

Chapter One provided the structural context for this study. The background summarized critical concepts presented in Chapter Two with respect to the importance of metacognitive development to the learning process, the metacognitive strengths and weaknesses in gifted and high-achieving learners, and the benefits of writing in the mathematical problem-solving process and its impact on metacognitive development. Thereafter, the Statement of the Problem presented a synthesized account of the literature and presented the need for research to identify strategies to develop cognitive regulatory skills in gifted learners for which this study desires to fill. The Purpose of the Study provided a description of the qualitative research methods utilized in this study. The research questions in this study were communicated to serve as a guide for the research and methodology of the study, and the Rationale for the Study served to provide a description of why the study is warranted and how it could add to the current field of research. A description of the researcher's background in mathematics, writing, and gifted and high-achieving education was presented along with the researcher's relationship to the problem. A definition of terms was provided in order to clarify the meaning of important terms within the study. This chapter served as an outline to frame the study in better understanding the cognitive regulatory experiences of gifted and high-achieving learners when writing is used in the mathematical problem-solving process.

CHAPTER TWO: Literature Review

Introduction

Prior to the accountability movement in education, gifted and high-achieving students were often the ones overlooked because they typically performed well on assessments of academic achievement. However, when additional measures, such as academic growth, began to be taken into consideration and analyzed, it was determined that gifted and high-achieving learners actually gained little to no knowledge during an academic year (Camilli, 2008; Johnsen 2014; Loveless et al., 2008; Plucker, 2015; Sanders & Horn, 1998; Spielhagen, 2012). It is important for educators to ensure all students are receiving an appropriate amount of academic growth each year. Therefore, we must examine the principles of effective learning to identify an area in which gifted and high-achieving students can improve and that will translate to academic growth for these learners.

Metacognition is one principle of effective learning in which gifted and high-achieving learners have room for improvement (Ablard & Lipschultz, 1998; Alexander & Schwanenflugel, 1996; Bandura 1993; Carr, Alexander & Schwanenflugel, 1996; Kramarski et al., 2001; Yildiz, Baltaci, & Güven, 2011). Even though gifted and high-achieving learners tend to perform better in the cognitive knowledge aspect of metacognition than their peers, they still struggle with the management aspect of their cognitive skills known as cognitive regulation (Alexander & Schwanenflugel, 1996; Arslan & Akin, 2014; Carr et al., 1996; Lawson & Chinnappan, 1994; Swanson, 1992; Yildiz et al., 2011). However, little research exists to identify effective strategies that specifically target the development of cognitive regulatory skills and to determine if, in fact, the development of cognitive regulatory skills alone will have a positive impact on academic achievement in gifted and high-achieving learners.

Gifted and High-Achieving Learners

Gifted Learners

A gifted learner typically refers to a student who performs exceptionally well in one area or another and is identified by a person professionally trained in the identification of gifted and talented learners (Kaufman, 1976). Originally, gifted learners were identified based upon the determination of their IQ (Jolly, 2005). However, psychological and educational professionals felt some gifted students may exhibit their talents in manners other than IQ. In 2004, the federal government provided a definition to help clarify the designation of gifted and talent students. The No Child Left Behind Act provides:

> The term "gifted and talented students" means students, children, or youth who give evidence of high performance capability in areas such as intellectual, creative, artistic, or leadership capacity, or in specific academic fields, and who require services or activities not ordinarily provided by the school in order to fully develop such capabilities. (20 USC 7801, 2004)

While IQ is not a part of the federal definition, it is still one of the measures used by many states in the identification process of gifted and talented students (Jolly, 2005).

Characteristics of gifted learners. Although each gifted learner can express their giftedness in a unique manner, there are certain characteristics that gifted learners in general tend to exhibit (Winebrenner, 2001). From an academic perspective, gifted students tend to learn faster and at an earlier age, to remember things better, and to deal with complex concepts better than their peers (Clark, 2013, Winebrenner, 2001). In addition, gifted learners are usually intensely passionate about one or two topics and can utilize multiple brain channels at one time. They also come up with faster, more efficient ways to accomplish tasks and persistently want to share what they know. Giftedness also comes with its challenges. Learners with gifted IQs typically have a perfectionist nature, become intolerant of work that is not perfect, and are intensely sensitive to criticism. To help gifted learners through these issues, teachers should communicate to students that learning is a struggle, provide them with challenging tasks that could lead to academic frustration, and encourage them to try tasks that are difficult (Winebrenner, 2001).

Educators' responsibility to the academic growth of gifted learners. Winebrenner (2001) states, "A teacher's responsibility is to teach the students, and to make sure that all students learn new content every day" (p. 1). Gifted students are no exception (Winebrenner, 2001). It is a myth that gifted students are not an at-risk group, and it is the teachers' responsibility to work and to cultivate the giftedness in gifted learners (Clark, 2013). In fact, not meeting the needs of these learners can have a negative impact on society as well as the student. When the needs of gifted learners are not appropriately met, they tend to regress, and society needs gifted students to fill demanding and innovative roles in our world. Although gifted learners tend to acquire an extraordinary amount of information quickly and retain that information successfully, many gifted learners have been unable to meet their potential in the classroom (Clark, 2013; Wilkins, Wilkins, & Oliver, 2006; Winebrenner, 2001). Typically, they do not know how to effectively study and have not had the chance to produce exceptional work, because their full potential has remained untapped (Clark, 2013).

Being that gifted learners are an at-risk group, it is the responsibility of educators to identify strategies that will positively impact the academic growth of gifted learners (Clark, 2013; Johnsen, 2014; Winebrenner, 2001). Because gifted learners tend to perform well academically, identifying an area of potential opportunity could prove to be a challenging task (Winebrenner, 2001). To begin investigating this concern, it is important to understand what principles influence effective learning.

High-Achieving Learners

Teachers often recognize gifted learners as those who are high-achieving (Clark, 2013). However, gifted learners and high-achieving learners are not mutually exclusive and overlap between the groups can exist (Guzy, 2008). Although there is no specific distinction between gifted and high-achieving learners, there are few characteristics that classify students as high-achieving (Clark, 2013). High-achieving learners get good grades, are self-focused, goal driven, committed, and continually striving for improvement (Clark, 2013; Jones & Spooner, 2006; Wiesman, 2013). Also, they typically perform better with learning based on knowledge and comprehension and are usually highly accomplished (Clark, 2013). High-achievers can grow to develop their giftedness by being provided with additional opportunities to develop themselves as learners.

Educators' responsibility to the academic growth of high-achieving learners. Since the inception of the NCLB, academic growth in high-achieving learners has decreased (Camilli, 2008; Loveless et al., 2008). It seems both gifted and high-achieving learners alike are being ignored and unable to meet their full potential (Morisano & Shore, 2010). Researchers feel focus needs to be brought back to ensuring the growth of high-achieving students in order for our country to remain competitive (Camilli, 2008; Loveless et al., 2008; Plucker, 2015). Teachers need and desire new strategies to help increase the academic achievement and growth of high-achieving learners (Camilli, 2008; Loveless et al., 2008).

Principles of Effective Learning

Learning is a complex process that involves psychological, developmental, and cognitive aspects (Vosniadou, 2001). Continual educational research provides insight on the most efficient and effective methods for the education of children through the learning process. Education is the process of directing change in one's behavior (Keel & Rowland, 1974). When teachers use research-based principles to educate students through the learning process, students tend to learn more effectively (Vosniadou, 2001).

These principles guide the development of our learning environment, the development of a learner's cognitive functioning, and the consideration of the individual needs of the students. The active involvement of students in the learning process, the benefits of collaboration and social interaction during learning, and the engaging in meaningful activities, such as those to enrich oral and written communication skills, relate to principles for developing effective learning environments (Brown, Ash, Rutherford, Nakagawa, Gordon, & Campione, 1993; Brown, Collins, & Duguid, 1989; Piaget, 1978; Scardamalia & Bereiter, 1991; Vosniadou, 2001; Vygotsky, 1978). Teachers can aid in the development of a child's cognitive functioning by teaching students to understand, reason, and solve problems strategically and instruct students on the skills required for effective self-reflection (Martin & Booth, 1997; Palinscar & Brown, 1983; Vosniadou, 2001; White & Fredericksen, 1998). Another principle to facilitate effective learning requires taking into consideration the individual needs of students (Chekwa, Krechevsky, Divine, & Dorius, 2014; Gardner, 2011; Vosniadou, 2001).

Researchers consider the development of cognitive and metacognitive strategies as one of the most important ingredients in the learning process and a process in need of the most attention (Flavell, 1979; Perkins, 1995).

Metacognition

The importance of self-reflection on the learning process has been a topic of study among theorists and researchers for many years (Hammond, Austin, Orcutt, & Russo, 2001). Even Plato's early teachings referenced the significance of self-reflection and the understanding of one's own thinking on the learning process. Since self-reflection is a vital element of how we learn, educators should encourage students to practice monitoring their own thought processes (Fox & Riconscente, 2008; Hammonds et al., 2001). Most adults have the ability to monitor their own thinking; however, this ability does not come as easily to children (Vygotsky, 1978). Children need to be taught the skills of self-reflection and thought monitoring to aid in their learning.

It was not until the 1970s when Flavell coined the term metacognition to refer to the monitoring of one's cognitive abilities (Flavell, 1979; Veenman, Van Hout-Wolters, & Afflerbach, 2006). Metacognition also involves reflecting upon one's thoughts as well as knowing what, when, why, and how a problem should be solved (Chekwa et al., 2014; Flavell, 1979). This process typically involves a higher order of thinking that leads to comprehension (Chekwa et al., 2014).

The Reflective Learning System

The skill of reflection is controlled by the most complex learning system known as the reflective learning system (Given, 2002). It is the learning system that manages all other brain functions and is the last of the brain functions to develop. Reflection is a learnable intelligence that should be nurtured (Perkins, 1995). Yet, the lack of sufficient instruction on the appropriate use of reflective thought concerns researchers. Perkins (1995) states:

> Hardly anything in conventional educational practice promotes, in a direct and straightforward way, thoughtfulness and the use of strategies to guide thinking. Those students who acquire reflective intelligence build it on their own, by working out personal repertoires of strategies. Or they pick it up from the home environment, where some parents more than others model good reasoning in dinner table conversation, press their children to think out decisions, emphasize the importance of a systematic approach to school work, and so on. (p. 117)

Teaching the appropriate use of reflection is an area of critical need in education (Given, 2002). If we continue to neglect the direct instruction of the use and importance of reflective behaviors, impulsive and anti-social behaviors can ensue. It is through reflective learning along with the fostering of self-monitoring and personal management skills that students reach higher levels of learning.

Facets of Metacognition

Since early educational research related to metacognition began, several terms have become synonymous with the subject (Veenman et al., 2006). Theory of the mind, executive skills, self-regulation, heuristic strategies, and comprehension monitoring are just a few phrases that relate to the topic of metacognition. Although these areas pertain to some form of metacognitive functions, the cognitive monitoring process occurs when certain factors of metacognition interact with one another: cognitive knowledge, cognitive experiences, and cognitive regulation (Brown & DeLoache, 1978; Cross & Paris, 1988; Flavell, 1979; Schraw, Crippen, & Hartley, 2006; Veenman et al., 2006; Vrugt & Oort, 2008).

Cognitive knowledge refers to stored knowledge one uses to evoke actions and experiences to carry out tasks and to achieve goals, or the process of thinking about one's actions when carrying out a task or working to achieve a goal (Cao & Netfield, 2007; Flavell, 1979). It is the relationship between the person, the goal or task at hand, and the actions or strategies used throughout the problem-solving process (Flavell, 1979). This awareness of one's thinking during the problem-solving process can help students better organize and refine their thoughts (Ashman, Wright, & Conway, 1994). It involves the person's ability to select, evaluate, revise, and possibly abandon cognitive tasks (Flavell, 1979). However, metacognitive knowledge can be right or wrong and can be difficult to change (Flavell, 1979; Veenman et al., 2006).

There are three main categories of cognitive knowledge: declarative knowledge, procedural knowledge, and conditional knowledge (Cross & Paris, 1988; Paris et al., 1983; Vrugt & Oort, 2008). Declarative knowledge, otherwise referred to as person and task knowledge, is the understanding of *what* factors influence cognitive tasks (Cross & Paris, 1988; Flavell, 1979; Schraw et al., 2006). It involves knowing oneself as a learner and understanding factors that affect cognitive development. Knowing *how* skills should be executed or applied is known as procedural knowledge or strategy knowledge (Brown & DeLoache, 1978; Cross & Paris, 1988; Schraw et al., 2006; Veenman et al., 2006). Procedural knowledge involves being aware of what strategies are available to manage cognitive tasks. Finally, conditional knowledge involves *when* strategies should be used and *why* the chosen strategy is the most effective.

Cognitive knowledge leads to cognitive experiences (Flavell, 1979). Cognitive experiences involve the awareness of one's feelings throughout the thinking process. Such experiences can be brief or lengthy, simple or complex, and can lead to a variety of feelings before, during, and after the cognitive experience, such as a sense of being puzzled, or the conjuring of feelings one has previously felt during a similar cognitive experience. The feelings evoked from these occurrences are typically caused by the stage a person is in during the problem-solving process and whether they are likely to succeed in the task at hand.

Cognitive knowledge and cognitive experiences are typically not mutually exclusive (Flavell, 1979). Cognitive experiences can lead a person to evaluate their current plan of action and eventually create, abandon, or revise goals. Additionally, cognitive experiences can help a person activate cognitive or metacognitive strategies to aid in accomplishing the task at hand. Flavell (1979) states that "cognitive strategies are invoked to make cognitive progress" (p. 909), and "metacognitive strategies are used to monitor it" (p. 909). However, there are some strategies that work to achieve both cognitive and metacognitive goals.

Cognitive regulation is the mental activity of managing cognitive tasks (Cross & Paris, 1988; Paris et al., 1983). Planning, monitoring or regulating, and evaluating are factors involved in cognitive monitoring (Cross & Paris, 1988; Paris et al., 1983; Schraw et al., 2006; Weinstein & Mayer, 1986). The process of selecting a strategy or strategies in order to achieve a goal or complete a given task relates to the self-regulation function of planning. Monitoring or regulating involves the ability to analyze a task in conjunction with one's personal abilities that may have an effect on the outcome of the cognitive task. Prior cognitive experiences have an impact on the monitoring process of cognitive regulation (Flavell, 1979). Finally, evaluation includes assessing the process and products of learning and using that assessment to revisit and to revise learning goals throughout a cognitive task (Cross & Paris, 1988; Schraw et al., 2006).

Benefits of Metacognitive Development

The development of metacognition and metacognitive skills are critical to successful learning (Chekwa et al., 2014). Metacognitive development can positively influence the learning process in various ways. It can help students become more aware of their own knowledge, specifically making the determination between what they know and do not know in a specific content area (Cao & Nietfeld, 2007). It helps students increase skills that can have a lasting impact on academic achievement such as providing students with a means to organize and to enhance their thinking (Ashman et al., 1994; Schraw & Graham, 1997). Metacognitive development can also help students become more independent during the problem-solving process, examine and modify their mental abilities, and contribute more during the completion of a cognitive task (Schraw & Graham, 1997; Stan, 2012). The development of metacognitive abilities can result in significant gains in student achievement (Cross & Paris, 1988).

Children should be taught skills to increase their metacognitive abilities (Flavell, 1979). While standard instruction in the classroom targets mastery of content knowledge rather than analysis of thinking, research shows that incorporating specific instruction on the development of metacognitive skills can improve students' personal achievement (Cross & Paris, 1988; Tok, 2013). By providing students with targeted instruction on the process involved in understanding cognitive tasks and in evaluating various strategies during problem-solving, students can acquire the capacity to generalize these skills and to apply them in other related tasks.

Teaching strategies alone is not enough (Perkins, 1995). Cognitive knowledge and cognitive regulation skills should be taught in conjunction with cognitive strategies, so students can understand when certain strategies will aid in accurately completing the goal or task and which one of those strategies is the most effective (Cross & Paris, 1988; Paris, Lipson, & Wixson, 1983; Perkins, 1995). By becoming aware of what one knows and does not know and evaluating the effectiveness of selected strategies, students learn to monitor and adjust their thinking, to regulate their own learning, and to further contribute to the problem-solving process (Schraw & Graham, 1997; Stan, 2012). Using reflective intelligence strategies, such as cognitive regulation strategies, can even help people behave more intelligently in certain domains (Perkins, 1995). The use of these strategies may not have a direct impact on increasing a person's IQ, yet their use can help people to expand their inventory of strategies to increase knowledge acquisition, which can lead to more intelligent behavior. Thus, strategy knowledge and self-monitoring can be a powerful influence on intelligent behavior (Perkins, 1995).

Issues Arising from a Lack of Metacognitive Development

Although some metacognitive skills come along with maturity, it takes direct instruction to build others (Darling-Hammond, Austin, Cheung, & Martin, 2003). If these skills are not directly taught, students typically do not know how to plan the necessary steps in order to complete a task, to monitor their thinking during completion of the task, and do not realize that various strategies exist to help them solve problems (Darling-Hammond et al., 2003; Veenman et al., 2006). Typically, if these skills are developed, students perform well (Veenman et al., 2006). However, if these skills are not developed or not used, students tend not to plan and their performance is negatively affected.

A lack of metacognitive development may also affect students' awareness of their own understanding and impact their metacognitive experiences (Brown, Bransford, Ferrara, & Campione, 1982; Darling-Hammond et al., 2003). Students who have not been instructed in cognitive knowledge skills may not be able to appropriately describe their thought process and differentiate between what they know and do not know when it comes to problem-solving (Brown et al., 1982). They may not know how to ask questions to help them through the problem-solving process, because they are not aware of the point in the process when their thinking went awry (Darling-Hammond et al., 2003). This lack of awareness can also prevent students from being able to redirect their thinking when they get frustrated or confused during the problem-solving process. When students do not have the metacognitive skills to help them monitor and adjust their thinking when a task gets difficult, it can cause students to develop feelings of frustration and discouragement which can lead to negative metacognitive experiences (Darling-Hammond et al., 2003; Flavell, 1979).

The Development of Metacognition

Although many students gain metacognitive behaviors from others in their lives such as parents and peers, direct metacognitive instruction is necessary to further develop these skills (Alexander & Swanenflugal, 1996; Jaušovec, 1994; Mok, Lung, Cheng, Cheung, & Ng, 2006, Veenman et al., 2006). Some students have more opportunities to gain and employ their metacognitive skills than others (Veenman et al., 2006). Thus, educators should provide all students with the knowledge, skills, and opportunities to further their metacognitive development (Flavell, 1979; Given, 2002). It is also important for teachers to understand that students may have the metacognitive abilities, yet additional factors may prevent them from exercising such skills (Veenman et al., 2006). These factors include task difficulty, test anxiety, lack of motivation, along with students not seeing the benefit of utilizing metacognitive skills. Therefore, teachers should not only teach students cognitive knowledge strategies, but also cognitive regulation strategies to help students determine when utilizing this knowledge and these skills is applicable (Cross & Paris, 1988; Darling-Hammond et al., 2003; Paris et al., 1983; Perkins, 1995).

One of the main goals of teachers should be fostering the cognitive regulation skill of reflective thought (Given, 2002). The reflective thought process can positively impact the learning process by guiding students to higher order thinking by revealing insights on their own thoughts and actions. The art of reflective thinking and metacognition should be intently taught to students. An integrative-strategies approach can serve to properly foster metacognitive thinking. Using this approach, teachers teach a skill directly related to metacognitive or reflective thought and then integrate this skill into course content (Cross & Paris, 1988; Given, 2002; Paris et al., 1983; Perkins, 1995). It is necessary to teach the skill continuously and intentionally until students internalize the process (Given, 2002). Teachers can directly instruct students on the use of reflective thinking by modeling evaluative questioning techniques to show students how to critique and to assess their own thinking.

Research on metacognition has shown certain best practices are more effective in the development of metacognitive skills. Veenman, Van Holt-Wolters, & Afflerbach (2006) assert there are three fundamental principles for successful metacognitive instruction. First, teachers should embed metacognitive instruction in content matter instruction in order to develop a connection between knowledge, skills, and the use of metacognitive skills in true context (Veenman et al., 2006). Second, students need to be informed of the impact of metacognitive instruction. Although the use of metacognitive skills may require additional effort on the front end, if used appropriately, the development of these skills can be useful. Third, educators should engage in prolonged and consistent metacognitive instruction. In addition, many researchers proclaim the use of the WWW&H Rule during metacognitive instruction (Brown & DeLoache, 1978; Cross & Paris, 1988; Veenman et al., 2006). This rule encourages students to focus on what strategies to employ, when to employ such strategies, why the chosen strategy should be used, and how the strategy should be appropriately used.

Metacognition and Academic Achievement

Cross and Paris (1988) studied the relationship between metacognitive ability and reading comprehension in 171 third and fifth grade children. Students were introduced to the Informed

Strategies for Learning (ISL) curriculum which was designed as a metacognitive approach to help students in identifying their awareness and use of certain reading comprehension strategies. The ISL curriculum focused on the development of the cognitive knowledge aspects of declarative, procedural, and conditional knowledge. The results of the study showed a strong correlation between metacognitive knowledge development and the increase of reading comprehension. Students in both grade levels made significant gains in both their metacognitive knowledge skill development and their reading comprehension.

Chekwa, McFadden, Divine, and Dorius (2014) researched the effects of targeted metacognitive instruction on academic achievement. The study involved students who attended the Metacognition Lab at Miles College (Chekwa et al., 2014). This lab was designed to solely provide instruction on metacognitive skills to help students increase their cognitive awareness, monitor their individual earning process, manage their cognitive abilities, and identify areas of deficiency in their cognitive knowledge. After the first year, students' GPAs were analyzed and compared to their GPA prior to their work with the Metacognition Lab. Overall, students who used the lab had an average increase of 12% in their GPA. For students whose GPA started out below 2.0, there was over a 40% increase in their GPA. After the second year of the lab's operation, the results were similar. The average increase in participating students' GPA was 8%, while students whose GPA was less than 2.0 presented an increase of 55% in their GPA. While this study did not provide specifics on the metacognitive activities used in the Metacognition Lab, it does provide further evidence that an increase in metacognitive abilities can positively impact academic achievement.

Metacognition and Mathematics

Metacognition plays an important role in mathematical skills and understanding (Lester, 1994; McCormick, 2010). It serves as the basis of effective problem-solving (Lester, 1994). Metacognitive abilities can help students to learn the process of mathematics, to deepen their mathematical understanding, and to learn the language of mathematics (McCormick, 2010).

Benefits in mathematics from metacognitive development. When students are explicitly taught to engage in various metacognitive processes throughout the problem-solving process, their overall mathematical performance improves (Garofalo & Lester, 1985; Pugalee, 2001; Young, 2010). Specifically, the development of metacognition in mathematics is vital to solving challenging mathematical tasks (Carr, Alexander, & Folds-Bennett, 1994). Although most children tend to have some cognitive knowledge about various mathematical strategies, increasing strategy knowledge can play an important role in a student's academic achievement (Carr et al., 1994; Garafalo & Lester, 1985). Mathematical cognitive knowledge can help students to solve complex problems that require higher-order thinking skills (Carr et al., 1994). Carr, Alexander, and Folds-Bennett (1996) assert that even children in elementary school have the potential to gain specific strategy or procedural knowledge to help when presented with challenging tasks. Additionally, when students are specifically taught the cognitive regulation skills of planning, monitoring or regulating, and evaluating throughout the problem-solving process, achievement increases (Charles & Lester, 1984). Research suggests that relationships between metacognition and achievement exists for older students (Carr et al., 1994; Cross & Paris, 1988).

Metacognition, math, and academic achievement. In 1945, Stanford University professor George Polya wrote a groundbreaking book on the importance of strategic thinking skills on mathematical performance (Polya, 1957). Polya states that intelligent problem solvers ask questions and make connects to aid in solving mathematical tasks. His questioning urges students to build upon prior experiences to help derive metacognitive and cognitive abilities which would be beneficial to solving problems, to developing a strategic plan to solve problems based upon their cognitive knowledge and prior metacognitive experiences, to using conditional knowledge to determine if there is a better way to solve the problem, and to evaluating the solution to ensure its accuracy. He coupled these questions with a modern heuristics approach to develop a four-step approach to problem-solving. The four phases of his approach include understanding what the problem is asking, creating a plan to solve it, executing the plan to derive a solution, and evaluating both the solution and the work involved to ensure accuracy. Polya's book pioneered the research on the relationship between metacognitive abilities and mathematics.

Schoenfeld (1982) carried the work of Polya (1957) even further. He recognized that even after being instructed in the problem-solving heuristics described by Polya (1957), students were not incorporating these strategies into their mathematical problem-solving tasks (Schoenfeld, 1982a; Schoenfeld, 1982b, Schoenfeld, 1985). After researching the issue, Schoenfeld discovered this lack of implementation was due to a lack of mental management. He sought to determine if by directly instructing students on metacognitive knowledge and metacognitive regulation would cause students to implement Polya's (1945) heuristic strategies and, thus, impact student academic achievement (Schoenfeld, 1982a; Schoenfeld, 1982b). Shoenfeld provided students with a mental strategy to help students keep track of their problem-solving efforts (Schoenfeld, 1982a; Schoenfeld, 1982a; Schoenfeld, 1985). This strategy included some of the heuristic methods outlined by Polya (1957) along with changes made by

Schoenfeld to create a five-phase model for mathematical problem-solving. These phases include: analysis, design, exploration, implementation, and verification. Each of these phases is similar to those outlined by Polya (1957) with the exception of the exploration phase. In this phase, students are encouraged to explore new or additional strategies that would aid in the solution to the problem. Schoenfeld taught this approach to a treatment group while the control group was not introduced. Each group had the same homework assignments, yet the treatment group was encouraged to incorporate the five-phase model while completing their homework. At the end of the study, the academic achievement of the treatment group doubled from before and after the study, while the control group did not exhibit any increase.

During the time period when much of the focus on educational research surrounded metacognition and cognitive development, Garofalo and Lester (1985) researched on the impact of metacognition and cognitive development on mathematical performance. Their findings concluded that merely paying attention to cognitive abilities in mathematics is not sufficient in and of itself (Garofalo & Lester, 1985). For optimal mathematical performance, attention needs to be given to metacognitive development. Educators of mathematics should embrace a culture of metacognition within the classroom. However, Garofalo and Lester suggest additional research needs to be performed to learn about effective instructional strategies in mathematics to develop this metacognitive mindset and to determine how the relationship between one's cognitive knowledge affects the ability to effectively regulate their thinking.

In 1990, Pokay and Blumenfeld studied the relationship between student motivation, the use of cognitive strategies, and metacognitive knowledge in predicting achievement in geometry both early and late in the semester. Early in the semester, the study showed both motivation and the use of cognitive strategies had a positive influence on the mathematical achievement (Pokay

& Blumenfeld, 1990). Yet, students who used metacognitive strategies early in the semester did not perform as well in mathematical achievement. However, when comparing performance of the students who used cognitive strategies to those who used metacognitive strategies at the end of the semester, those who used metacognitive strategies in problem-solving had higher academic achievement. These findings suggest that strategy use may need to shift from a focus on cognitive strategy use at the beginning of the semester to that of a metacognitive strategy approach at the end of the semester as the intensity of the course increases.

Carr, Alexander, and Folds-Bennett (1994) examined the relationship between mathematics strategies and metacognition. The three specific strategies in question are external strategies, such as counting on fingers; internal strategies, such as performing mathematical functions in one's head; and retrieval, such as rote memorization of math facts (Carr et al., 1994). The study resulted in a nonsignificant relationship between metacognition and external strategies and retrieval. The results of the study did show that the development of metacognition influences children's internal strategy use. Yet, the study does not specify which aspect of metacognition attributes to accurate internal strategy use.

Metacognitive development plays an important role in a student's mathematical success. Many researchers have asserted that students with more developed metacognitive abilities perform better in mathematical tasks and tend to have a deeper understanding of mathematical concepts (Carr et al., 1994; Garofalo & Lester, 1985; Polya, 1957; Pokay & Blumenfeld, 1990; Pugalee, 2001; Schoenfeld, 1982a; Schoenfeld, 1982b; Schoenfeld, 1985). Although the development of metacognitive skills may take some time and effort to produce positive academic results, the long term results prove these skills can be highly beneficial to students (Pokay & Blumenfeld, 1990).

There have been numerous studies emphasizing the positive impact of metacognition on learning and academic achievement. Several research studies have consistently resulted in a positive relationship between the direct instruction of metacognitive abilities and the increase in academic achievement (Chekwa et al., 2014; Cross & Paris, 1988; Pokay & Blumenfeld). However, the participants in these studies were not identified as gifted learners. Thus, we must determine if this positive relationship between metacognition and academic achievement holds true when gifted learners are involved.

Metacognition and Gifted Learners

Gifted learners often have metacognitive abilities that greatly exceed that of students of average IQs (Alexander & Schwanenflugel, 1996; Swanson, 1992). These metacognitive skills are also inclined to develop at earlier ages in gifted learners rather than non-gifted learners (Alexander & Schwanenflugel, 1996; Schraw & Graham, 1997). Specifically, the specific strategy knowledge, or procedural knowledge, of gifted learners is more advanced (Alexander & Schwanenflugel, 1996; Carr et al., 1996; Jacobs & Paris, 1987; Pintrich, 2002; Swanson, 1992). They are more likely to be aware of general strategies used to solve problems, to employ those strategies in the problem-solving process, and to solve such problems more efficiently than other students.

When gifted learners are explicitly taught strategies to further their metacognitive skills, they can improve their problem-solving abilities (Tan & Garces-Bascal, 2013). Incorporating research-based strategies that are differentiated for gifted learners can help gifted learners increase their metacognitive abilities (Schraw & Graham, 1997; Wilkins et al., 2006). Since gifted students rapidly learn new information and tend to retain that information well, teachers can provide gifted learners with the differentiation they need by integrating activities that encourage creativity and independence (Wilkins et al., 2006). One example of integrating creativity and independence is asking students to develop their own math problems similar to the one solved (Card, 1996; Van der Stel, Veenman, Deelen, & Haenen, 2010). Gifted students also perform well in making generalizations (Wilkins et al., 2006). Therefore, another activity to advance metacognitive abilities in gifted learners is to ask students to develop their own generalizations or rules when it comes to problems they have solved.

The importance of metacognitive development in gifted learners. Although gifted learners usually have more advanced metacognitive skills, there are areas related to metacognition in which improvements can be made (Alexander & Schwanenflugel, 1996; Carr et al., 1996; Schraw & Graham, 1997; Jauśovec, 1994; Yildiz, Baltaci & Güven, 2011). Carr, Alexander, and Schwanenflugel (1996) assert that all learners, including gifted learners, struggle with the function of cognitive regulation. Cognitive regulation involves the processes of planning, monitoring or regulating, and evaluating the cognitive thinking during the completion of the task (Jacobs & Paris, 1987; Pintrich, 2002). Gifted learners can typically choose a strategy which can be used to solve a problem and utilize it effectively; however, they struggle with analyzing all the available strategies and determining if a better strategy exists in their knowledge bank (Carr et al., 1996). However, subsequent research completed by Yildiz, Baltaci, and Güven (2011) asserted that gifted learners were good at some cognitive regulation skills, such as planning and monitoring, yet struggled with the skill of evaluating their work. In addition, Jauśovec (1994) determined gifted students who receive direct instruction on metacognitive skills performed better at using these strategies on closed problems than on open problems which typically require creativity.

Benefits to gifted learners from metacognitive development. Since metacognition is vital to the learning process, teachers should provide direct instruction to gifted learners to continually advance their metacognitive skills (Alexander & Swanenflugal, 1996; Jauśovec, 1994; Mok et al., 2006). By candidly working with gifted learners to develop their metacognitive skills, teachers can help propel the thinking of gifted learners to a higher level (Schraw & Graham, 1997).

Metacognitive development in gifted learners. Alexander and Schwanenflugel (1996) studied the development of metacognition in both gifted and non-gifted children. Their findings further confirmed the work of Carr, Alexander, and Schwanenflugel (1995) that gifted students consistently have a more developed understanding of declarative knowledge than non-gifted students (Alexander & Schwanenflugel, 1996). However, their research suggests this declarative knowledge advantage of gifted students appears to have a ceiling effect which tops out around the fourth grade. Their findings also propose that while more intelligent children tend to have a more advanced development of specific metacognitive knowledge, they do not always use this knowledge appropriately to regulate their cognitive knowledge thinking and choose the strategy which would be the most effective and efficient in completing the task. Additionally, Alexander and Schwanenflugel suggest additional research should be completed related to the development of the specific types of metacognitive abilities in relation to the performance of gifted students.

With respect to research surrounding metacognition and the gifted learner, scholars seem to be consistent in their findings that gifted students tend to have metacognitive behaviors, such as cognitive knowledge, which are more advanced than students with average IQs (Alexander & Schwanenflugel, 1996; Carr et al., 1996; Schraw & Graham, 1997; Swanson, 1992; Yildiz et al., 2011). Even with more advanced metacognitive abilities, direct metacognitive instruction has still proven to have a positive academic impact for gifted learners (Jauśovec, 1994; Schraw & Graham, 1997; Tan & Garces-Bascal, 2013). However, gifted students still have areas of metacognitive abilities in need of development, such as cognitive regulation (Alexander & Schwanenflugel, 1996; Carr et al., 1996; Yildiz et al., 2011).

Metacognition and High-Achieving Learners

Just like gifted learners, high-achieving learners tend to use more metacognitive strategies than that of other students (Doganay & Demir, 2011; Sun, 2013; Vanderstoep, Pintrich, & Fagerlin, 1996). They tend to be more self-regulated and less disruptive within the classroom (Vauras, Salonen, Lehitenen, & Lepola, 2001). High-achieving learners tend to have greater metacognitive knowledge skills and tend to have a greater amount of metacognitive management skills than lower achievers (Arslan & Akin, 2014; Lawson & Chinnappan, 1994). They can generate more solution paths, tend to notice errors, reference the problem, and use knowledge management skills to manage their thinking during the problem-solving process. In addition, high-achieving learners employ more self-regulated learning skills such as organizing, reviewing information, and seeking assistance although they may not always be aware they are employing these strategies because of their automaticity (Ablard & Lipschultz, 1988).

Metacognitive development in high-achieving learners. Several studies have shown how the direct training of metacognitive skills can result in the academic achievement of high-achieving students (Lioe, Ho, & Hedberg, 2005; Mevarech & Kramarski, 1997; Kramarski, Mevarech, & Arami, 2002). Even with their increased use of metacognition, high-achieving learners still have the opportunity to improve their metacognitive skills. Direct training in these areas can benefit high-achieving learners (Darling-Hammond et al., 2003; Given, 2002). High-achieving students struggle with the cognitive regulatory skill of taking what they know and applying it in different situations (Anderson, 1990; Bandura, 1993; Frye, 1989; Kramarski, Mevarech, & Lieberman, 2001). Additionally, Ablard and Lipschultz's (1988) study provided that high-achieving girls report a greater use of self-regulating strategies. Not only did this study show a variation on gender differences in the use of self-regulating skills, it also indicated that students exhibited their self-regulating skills in other different ways (Ablard & Lipschultz, 1988).

The Need for Further Research

While there has been a great deal of research surrounding metacognition in general, little research has been completed regarding specific metacognitive behaviors. Several of the studies referenced were either directed at general metacognitive behaviors or the study gave little evidence to determine if a specific type of metacognitive function was examined (Carr et al., 1994; Chekwa et al., 2014; Kramarski et al., 2002; Lioe et al., 2005; Mevarech & Kramarski, 1997; Pokay & Blumenfeld, 1990). Yet, studies from both Cross and Paris (1988) and Özcan and Erktin (2015) focused on strategies directed at developing cognitive knowledge in students.

Although many studies have investigated the effects of metacognition on academic achievement of all learners, gifted and high-achieving learners included, scholars suggest additional research related to the topic remains. Many of these recommendations indicate the need for research regarding specific aspects of metacognitive development. Alexander and Schwanenflugel (1996) call for additional studies on the development of specific areas of metacognition and the impact of that development on the academic performance of gifted learners. Considering the work of Alexander and Schwanenflugel (1996), Carr, Alexander, and Schwanenflugel (1996), Frye (1989), Kramarski, Mevarech, and Lieberman (2001), and Yildiz, Baltaci, and Güven (2011) all assert certain aspects of cognitive regulation are in need of development in gifted and high-achieving learners, additional research is required that focuses on the development of cognitive regulation in gifted and high-achieving learners and the effects of this instruction on academic performance. Therefore, there are two issues that need to be explored:

1) What strategies are effective in developing cognitive regulation skills in gifted and high-achieving learners?

2) Will the further development of cognitive regulatory skills in gifted learners positively affect their academic growth?

The Impact of Writing in Mathematics on the Development of Cognitive Regulation Skills in Gifted and High-Achieving Learners

In the field of education, writing instruction fits into one of two areas: learning to write and writing to learn (Knipper & Duggan, 2006). Typical writing instruction to aid in effective communication is known as learning to write. Writing to learn, however, refers to the use of the writing to foster student understanding and to help students make meaning of the content. Using writing to learn can also help students determine what they know and what they do not know, remember information or strategies previously learned, describe their thinking process, and ask appropriate questions as needed to acquire the content.

The process of writing can help students increase their cognitive skills and metacognitive abilities while constructing knowledge (Card, 1998; National Council of Teachers of Mathematics, 2000). Using research-based writing strategies during instruction and classroom activities can not only aid students in developing metacognition, but can also help promote communication, establish connections, and advance reasoning skills (Card, 1998; Schudmak, 2014). If writing has proven to have a positive impact on metacognition, could writing in mathematics serve as a strategy to help develop cognitive regulatory skills in gifted learners?

Writing and Mathematics

In today's mathematics classrooms, students are not only required to accurately solve problems, they are also expected to explain the strategies and steps used to derive their answer (Akpan & Beard, 2014). The focus has shifted to a skills based approach to a process based approach when teaching mathematics (Mills, O'Keefe, & Whitin, 1996). The parallel development of reading, writing, and mathematics can help in nurturing this process based approach. The major characteristics of the integration approach are a focus on the how children construct their own learning, the process of math, mathematical function, the social dimension of learning, and alternative communication.

When teachers use an integration approach to mathematics, students can develop the ability to speak and write mathematically and make meaning of mathematical concepts (Mills et al., 1996). The use of words, through speaking and writing, is critical to the function of reason (Polya, 1957). Moreover, it is through speaking and writing about mathematical processes that the mathematical thinking of students can be made visible (Whitin & Whitin, 2000). Writing and talking are also means to aid in the promotion of collaboration, discovery, and reflection. Encouraging students to engage in explicit discussions and writing about how students solve mathematical problems using accurate mathematical terminology helps students to develop their metacognitive ability and to deepen their understanding of mathematical concepts (National Council of Teachers of Mathematics, 2000).

Incorporating writing in mathematics instruction can positively impact the classroom (Whitin & Whitin, 2000). Mathematical authors write about what they know and develop connections to prior learning, discuss different cognitive strategies with others, initiate their own investigations, record their own discoveries, and revise and reflect on their work (Mills et al., 1996). It is through these writing experiences that students can build a collaborative mathematical learning community, express mathematical thinking in their own way, generate ideas, and reflect upon their personal mathematical conceptual understanding (Whitin & Whitin, 2000). Writing can also serve as a powerful teaching tool by providing educators with a window into the thought processes of their students.

Sharing of ideas through writing can help build a powerful community of mathematical thinkers (Whitin & Whitin, 2000). A collaborative community in the mathematics classroom highlights the process of math rather than focusing on the accuracy of the solution, recognizes that the thinking of others helps us to grow mathematically, and invites students to reflect upon their learning process and mathematical conceptual understanding. When developing a supportive classroom culture that promotes collaborative mathematical communication, teachers should build reflection time into their lessons, value mistakes as a means for learning, teach children differently based on their strengths and weaknesses, and develop communication in the classroom that depicts students as constructors of their own mathematical knowledge.

Writing during mathematics instruction can serve as a tool for mathematics discovery, emphasize strategic thinking, and promote personal expression, as well as, create a record of our mathematical thinking which we can then analyze and reflect (Whitin & Whitin, 2000). Students are encouraged to use the language of mathematics to speak, to write, to analyze, and to evaluate mathematical concepts (McCaster & Betts, 2007; Lynch & Bolyard, 2012). Each of these activities can show how students approach a problem, how they solve the problem, and why their process worked (McCormick, 2010).

Best practices for writing in mathematics. Teachers need to convey to the students that solving mathematical problem-solving is a process rather than just product (McCormick, 2010; Whitin & Whitin, 2000). Thus, students need to use writing to enlist metacognitive skills to guide them through the process (McCormick, 2010). Students can use writing to determine what the problem is asking, to identify and evaluate the various strategies which could be used to successfully solve the problem, to select the most effective and efficient strategy for the problem, to use the strategy to develop a solution, and to verify the appropriateness of the answer. Yet, prior to engaging in writing during mathematics instruction, teachers should be aware of fundamental principles that will not only encourage the use of mathematical language but that will also encourage metacognitive growth.

It is important for educators to experience the cognitive knowledge and cognitive regulation skills when writing in mathematics to effectively teach students this process (Kuzle, 2013). This not only helps teachers exercise their metacognitive thinking, it also helps teachers understand the perspective of their students through the learning process. After teachers gain experience in the writing process that focuses on metacognitive development, they should begin modeling and instructing students in the process (Schudmak, 2014). Teachers should model the use of writing through this problem-solving process and explicitly explain their thinking in writing (McCormick, 2010). This process should include showing students the step-by-step approach used to solve the problem, teaching students how to monitor one's own thinking throughout the problem-solving process, and evaluating the solution for reasonableness and accuracy (Schudmak, 2014). Thereafter, students should continually be encouraged to engage in writing activities throughout the problem-solving process incorporating the strategies modeled by their teacher.

When students begin the writing process, teachers should encourage students to choose their language carefully, provide time for verbal rehearsal of their thoughts, and highlight diverse journal entries (Whitin & Whitin, 2000). In addition, students should be provided with time to revise their thinking, make predictions, share their thought process, and reflect on the process. Allowing students to revise their thinking can help nurture positive mathematical thinking. Reflection time can be used to consider common computational or conceptual misunderstandings and analyze patterns.

Once students begin the writing process, teachers should begin analyzing their writing (Schudmak, 2014). Attention should be paid to the content of the response, the thought process used during teach stage of the process, and the time it took for the student to complete the analysis during each stage of the response. This analysis will not only help teachers discover the exact step where students' thinking when awry, if an error was made, but it will also help teachers find areas in which students may grow in mathematical understanding and metacognitive ability. Teachers should use this analysis to develop feedback for their students. Specific, meaningful feedback on students' writing is also necessary for metacognitive growth (McCormick, 2010). Teachers must constantly provide students with direct written and oral feedback about their writing in a timely fashion in order to deepen their mathematical understanding and metacognitive abilities (Card, 1998; Pugalee, 2001). Furthermore, students should be urged to read the feedback provided, to reflect upon how the feedback will enhance their learning, and to incorporate suggested changes into their future writing.

Research based writing strategies in math. There are several research-based strategies to incorporate writing into mathematics instruction (Whitin & Whitin, 2000). One strategy would be a written response to a story. Teachers can read a piece of literature that introduces an underlying mathematical concept. Either during or after the reading of the story, students record ways to solve the problem introduced and give reasons why one strategy may be better or different than another in the scenario which encourages the students' use of cognitive regulation skills. Students can also write their own story problems, engage in reflective writing, and use mathematical journals during mathematics instruction. During all writing, teachers should encourage metaphorical thinking, drawings, and diagrams to support the process.

Writing during the mathematical problem-solving process. The most researched area regarding mathematical writing involves writing during the problem-solving process. Lester (1994) asserts metacognition is the basis of effective problem-solving. Writing through the mathematical problem-solving process is one strategy that can help students develop their metacognitive abilities (Williams, 2003). Metacognitive knowledge, reflection, and skills are present when effective writing strategies are incorporated throughout each phase of the problem-solving process (Schudmak, 2014). Writing can be used as a tool to explore the meaning of problems, to reflect upon one's thinking during the problem-solving process, and to provide an overall reflection of the process, problem, and solution once the process is completed (Kuzle, 2013). Writing activities such as designing a plan to solve a problem, paraphrasing a problem, or evaluating the benefits of strategies which can be used to solve a problem can help grow metacognition in learning (McCormick, 2010; Van der Stel et al., 2010).

Students need direct instruction on how to appropriately write in the problem-solving process (Kuzle, 2013). Polya (1957), Pugalee (2001), and Schoenfeld (1982) worked to develop a process approach to mathematical problem-solving. Although their approaches differ somewhat, a few of the main phases include analysis, design or plan, exploration, implementation or execution, and verification (Polya, 1957; Pugalee, 2001; Schoenfeld, 1982).

The analysis phase refers to the student gaining a deep understanding of the problem. The next phase, design or plan, is where the student will plan how to strategically solve the problem. Exploration is a choice made by the student when they encounter difficulties through the process and cannot determine an appropriate path for solution (Schoenfeld, 1982). Once a tentative solution is derived, the student enters the implementation or execution phase where the proposed plan is carried out in hopes to lead to a solution (Polya, 1957, Pugalee, 2001; Schoenfeld, 1982). The last phase, verification, is where the student checks their problem for reasonableness and accuracy.

Writing, Metacognition, and Math

Pugalee (2001) presents a study on the how the use of writing through the problem-solving process can enhance metacognition. In this qualitative study, participants reviewed the writing of 20 ninth grade algebra students throughout each of four stages in the problem-solving process when solving math word problems (Pugalee, 2000). The four stages Pugalee used in his research included orientation, organization, execution, and verification. These stages are similar to those suggested by Polya (1957). The first of these stages is referred to as orientation (Garofalo & Lester, 1985; Pugalee, 2005). During this phase, students orient themselves with what the problem is asking. The second stage, organization, concerns organizing the information provided in the problem. Execution, the third stage, requires taking the information provided in the problem, selecting an appropriate strategy, and implementing the chosen strategy to derive a solution. The last stage, verification, involves using an alternative strategy or approach to ensure the solution is appropriate. Teachers should encourage metacognitive thinking in understanding the problem (orientation), devising a plan (organization), carrying it out (execution), and looking back through their work (verification) because students may make metacognitive decisions at one or all of the stages.

Pugalee's (2001) findings have several implications to the use of writing, metacognition, and mathematical problem-solving. First, mathematical learning can be increased when students writing through the problem-solving process in mathematics (Pugalee, 2001). Writing allows students to visualize their mathematical thinking and to reflect on their work in order to gain a deeper understanding of mathematical concepts. It can also help teachers easily identify areas in the execution process where student misconceptions occur. Second, writing during the mathematical problem-solving process can help further develop metacognitive abilities. Different metacognitive behaviors were present when students write during the problem-solving process rather. Writing helps students develop an essential link to their prior knowledge and increase the awareness of their thoughts during the problem-solving process. Thus, Puglaee suggests that mathematics teachers integrate a problem-solving approach which marries writing and metacognition. He did feel additional study was warranted to determine how, in fact, writing improves a students' metacognitive behaviors in order to develop instructional strategies to help deepen metacognitive understanding.

Özcan and Erktin (2015) determined that academic achievement in mathematics can increase by enhancing traditional mathematics homework with metacognitive questioning. The study involved a seventh grade classroom of a primary school to determine if questions specifically designed toward metacognitive thinking would further develop metacognition and, thus, increase academic achievement in mathematics (Özcan & Erktin, 2015). The purpose of the study was to determine if these questions would positively impact student academic achievement in the area of mathematics. The study compared the academic achievement of all students involved in the study prior to treatment. In addition to completing the homework assignments, the treatment group was asked to complete questions geared toward developing metacognitive skills. Most of the questions provided to the treatment group related to the students' use of metacognitive knowledge behaviors. After the treatment period, the academic achievement related to student performance on mathematics examinations of both the control and treatment groups were compared. The study results showed a significant academic difference between the scores of students whose mathematics homework was enhanced with metacognitive questioning and students who completed traditional mathematics homework. The academic achievement of the treatment group was significantly greater than that of the control group, thus furthering the evidence that increasing metacognitive skills can positively impact academic achievement.

Pugalee (2001), Özcan and Erktin (2015) studied the effects of implementing various writing strategies in the mathematical problem-solving process. Pugalee (2001) determined that not only did writing during the problem-solving process help deepen mathematical learning, but also increased the metacognitive skills of the students. Özcan and Erktin (2015) used metacognitive questioning during the problem-solving process on homework assignments. The results of this study demonstrated how using written responses to metacognitive questioning can help increase academic achievement and metacognitive behaviors.

Pugalee (2001) proposes additional research to determine if writing through the mathematical problem-solving process improves certain metacognitive behaviors.

The work of Polya (1957) and Schoenfeld (1982 & 1985) both describe a cognitive strategy to approach mathematical problem-solving. Schoenfeld added a mental management component to the original work of Polya. However, it was not until the work of Pugalee (2001) that writing was used as the vehicle for the completion of that cognitive process. Although Pugalee's work focused on metacognitive development in general, research is needed to determine the impact of writing on the individual components of metacognitive development, such as cognitive knowledge and cognitive regulation.

While these studies show that writing in mathematics can positively impact both metacognitive development and academic achievement in students, it remains to be seen if writing in mathematics can be used as a strategy to increase cognitive regulatory skills, or if writing in mathematics would affect the academic achievement of gifted learners.

Developing Writing Strategies in Mathematics for Gifted and High-Achieving Learners

By working to develop a metacognitive mindset in students throughout mathematical problem-solving, mathematical performance can increase (Garofalo & Lester, 1985; Pugalee, 2001; Young, 2010). However, writing activities for gifted and high-achieving learners should be differentiated from that of students with average IQs in order to promote metacognitive growth (Schraw & Graham, 1997; Wilkins et al., 2006; Wiesman, 2013).

In order to ensure the needs of gifted and high-achieving students are being met, teachers should exhibit certain behaviors within the classroom, enrich the curricula, and differentiate instruction (Clark, 2013; Wiseman, 2013; Winebrenner, 2001). Successful teachers of gifted and high-achieving learners display the following behaviors within the classroom: provide constant and constructive feedback, stimulate higher order mental processes, and vary their instructional strategies (Clark, 2013; Wiesman, 2013). These are all behaviors that can help gifted and high-achieving learners meet their potential and increase academic achievement. Enriching the curricula can also aid in gifted and high-achieving education and help learners to achieve academic success. Adding areas or skills not found in the regular content or curriculum is known as enrichment. When looking to enrich the curriculum to support the needs of gifted learners, teachers should focus on activities that encourage the use of research skills, critical thinking skills, and metacognitive skills (Clark, 2013). Differentiating the content refers to providing gifted learners with more complex text and compacting and accelerating the pace of instruction (Winebrenner, 2001). There are five main elements of differentiation: content, process, product, environment, and assessment. Process differentiation refers to altering methods students use to make sense of concepts or standards, such as providing opportunities for creative thinking and problem-solving. When the product is differentiated, gifted students are allowed to produce a different product during instruction. Differentiating the environment for gifted learners relates to developing a challenging classroom environment where differences are valued. Finally, assessment differentiation relates to altering the method of assessment for gifted learners. This could include the use of rubrics and independent study projects. In addition to enriching the curriculum and differentiation, the academic achievement of gifted learners can be positively impacted through integrating multiple disciplines, providing constructive and constant feedback, and offering students with experiences in learning (Clark, 2013).

Purpose of the Study

Since writing during the mathematical problem-solving process has proven to effectively increase both metacognitive skills and academic achievement, it may serve as a strategy to develop cognitive regulatory skills in gifted and high-achieving learners which could potentially have a positive impact on academic achievement.

The purpose of the study was to investigate the use of writing during the mathematical problem-solving process in gifted and high-achieving learners and its effects on the development of cognitive regulation and academic achievement.

Summary

Gifted and high-achieving learners deserve to learn new concepts and achieve academic success each day. It is the responsibility of teachers to ensure that all students, gifted and high-achieving students included, feel academic success daily (Loveless et al., 2008; Plucker, 2015; Winebrenner, 2001). Metacognition is a key component in the learning process which leads to academic achievement when used effectively (Cross & Paris, 1988; Chekwa et al., 2014). Targeted instruction of metacognitive skills has proven to be successful in increasing academic performance in gifted and high-achieving learners (Cross & Paris, 1988; Chekwa et al., 2014; Lioe, Ho, & Hedberg, 2005; Özcan & Erktin, 2015; Pokay & Blumenfeld, 1990; Schoenfeld, 1985; Victor, 2004). Yet, gifted and high-achieving learners do have metacognitive skills which are in need of further development (Ablard & Lipschultz, 1998; Alexander & Schwanenflugel, 1996; Bandura, 1993; Carr et al., 1996; Kramarski et al., 2001; Yildiz et al., 2011). Instruction of these skills has also proven beneficial in the mathematical problem-solving process (Garofalo & Lester, 1994; Schoenfeld, 1982a; Schoenfeld, 1982b; Schoenfeld, 1985; Pugalee, 2001). Writing is one strategy used to help deepen learning and increase metacognitive awareness and has proven beneficial to the development of metacognitive skills when used during the mathematical problem-solving process (Özcan & Erktin, 2015; Pugalee, 2001). Thus, researching the use of writing during the mathematical problem-solving process for gifted and high-achieving learners may be an effective method of increasing the cognitive regulation function in these learners as well as achieving an increase in academic achievement.

CHAPTER THREE: Research Methodology

The purpose of this phenomenological research study was to explore the lived experiences of gifted and high-achieving students and their cognitive regulatory development when implementing writing during the problem-solving process in mathematics. Current research suggests the cognitive regulatory aspect of metacognitive development is one area in which gifted and high-achieving students could improve (Ablard & Lipschulz, 1998; Alexander & Schwanenflugel, 1996; Bandura, 1993; Carr, et al., 1996; Kramarski et al., 2001; Schraw & Graham, 1997; Jauśovec, 1994; Yildiz, Baltaci & Güven, 2011). This study utilized a qualitative methodology to help gain a deeper understanding of how writing can impact cognitive regulatory development in gifted and high-achieving learners. This chapter provides a description of qualitative research, a description of phenomenology, a description of the study participants and setting, data collection procedures, ethical considerations, and data analysis procedures used during the completion of this study.

Qualitative Research

Marshall and Rossman (2011) define qualitative research as a "broad approach to the study of social phenomena" (p. 3). Qualitative research is used when there is a problem that needs to be explored to gain a complex, detailed understanding of the topic (Creswell, 2007; Marshall & Rossman, 2011). It helps to elicit unspoken knowledge, profound understanding, and individual interpretations of a given phenomenon (Marshall & Rossman, 2011). This form of research has become valuable in educational research in recent years. A qualitative approach was used in this study to gain rich descriptions of the cognitive regulatory experiences of gifted and high-achieving learners when writing during the problem-solving process.

Phenomenology

Phenomenology was utilized in this study to describe the cognitive regulatory experiences of gifted and high-achieving learners as they use writing in the mathematical problem-solving process. Mathematical problem-solving involves a complex, tacit web of cognitive and metacognitive processes. A phenomenological research approach seeks to accurately describe these experiences based upon the personal accounts of the individual involved in the phenomena.

Phenomenology is a genre of qualitative research where the researcher explores the lived experiences of individuals during a particular phenomenon (Creswell, 2007; Marshall & Rossman, 2011). Although Edward Husserl was credited with the formal development of phenomenological research, the method has deep philosophical origins that lead back to philosophers such as Kant and Hegel (Creswell, 2007; Moustakas, 1994). While there are different philosophical approaches to phenomenological research, all phenomenology focuses on describing the individual experiences of phenomena (Creswell, 2007; Yüksel & Yildirim, 2015; Kafle, 2013; van Manen, 1990). For the purposes of this study, a hermeneutical phenomenological research philosophy was utilized to describe the everyday lived experiences of an individual during a phenomenon and to provide an interpretation of its meaning (Creswell, 2007; van Manen, 1990).

There are various schools of thought related to methods of phenomenological research (Finlay, 2012). One facet of this debate involves the extent of researcher subjectivity. Most theorists purport the necessity for researchers to adopt a “phenomenological psychological attitude” in which a researcher should seek to keep an open mind throughout the research process in an attempt to see the experiences in a fresh, new way (Finlay, 2008; Finlay, 2012). Finlay

(2008) describes this attitude further as a dance between setting aside personal views and experiences during the research process and using the researcher's personal views and experiences to eliminate bias and to help see the experience in a true light.

There are four main processes involved in the phenomenological research method: *epoche*, *phenomenological reduction*, *imaginative variation*, and synthesizing the data to develop a true essence of the experience (Moustakas, 1994). The first method in this process is known as *epoche* and is derived from a Greek word meaning "to stay away from or abstain" (p. 85, Moustakas, 1994). Husserl believed that to gain a true understanding of the experience, it was necessary for the researcher to set aside any initial preconceptions or biases to obtain a true manifestation of the experience (Creswell, 2007; Moustakas, 1994). Thus, the researcher should reflect on their personal biases about the study in an attempt to bracket, or set aside, preconceived experiences to gain a fresh understanding of the experiences of the participants in the study (Creswell, 2007; Marshall & Rossman, 2011; Moustakas, 1994). Although many phenomenologists assert this is the first step in the phenomenological research process, Finlay (2012) suggests this bracketing of personal views and experiences is a continual process throughout a phenomenological study.

The next step in phenomenological research is the process of *phenomenological reduction* (Giorgi, 1997; Moustakas, 1994). This process involves describing the textural process of the experience by not only focusing on the external factors of the experience but also including the internal consciousness to truly describe the full experience between the participant and the phenomena. *Phenomenological reduction* involves a thorough review of the data to eliminate all elements within the data that does not directly relate to the essence of the experience (Yüskel & Yildirim, 2015). The data is then grouped by general topics or ideas to provide a textural description of the experience (Creswell, 2007).

Imaginative variation is the process in phenomenological research where a structural description of how the phenomena was experienced is written (Creswell, 2007; Moustakas, 1994). The researcher uses the textural descriptions derived in *phenomenological reduction* along with their imagination to develop structural themes (Moustakas, 1994; Yüskel & Yildirim, 2015). *Imaginative variation* is a process that seeks to find all possible explanations of the experience by changing the context about the phenomena and imagining all possible implications or perspectives about the phenomena (Creswell, 2007; Moustakas, 1994).

The final step in the phenomenological research process involves synthesizing the information to gain the essence of the experience (Moustakas, 1994). The researcher writes about the common experiences of the participants to provide the reader with an understanding of what it is like to experience the phenomena (Creswell, 2007; Moustakas, 1994).

Study Participants and Setting

Qualitative research studies necessitate a sampling of study participants who belong to the population described in the research question (Marshall & Rossman, 2011). In particular, phenomenological research requires a homogeneous group of participants who have experienced the same problem or phenomenon (Creswell, 2007). Researchers should select study participants who will purposefully inform the research problem and the phenomena. For the purposes of this study, criterion sampling for phenomenology was the selected methodology to identify the participants. Criterion sampling requires all participants to be a representation of people who have experienced the same phenomena (Creswell, 2007). When all participants experience the same phenomena, a higher level of quality assurance can be attained.

This study was conducted in a suburban elementary school district in the southeastern portion of the United States. The city where the school district lies has a population of about 108,000 people. The school district consists of 12 elementary schools with a district student population of approximately 7,500 students. The school district incorporates the gifted / high-achieving cluster group model in its schools during the time dedicated for response-to-intervention.

The participants in this study consisted of 12 students in the gifted / high-achieving cluster group classrooms for fifth and sixth grade. The researcher selected students from the gifted / high-achieving cluster group classroom and observed the learners from that classroom. The researcher served as teacher of the gifted / high-achieving cluster group and implemented writing strategies during the problem-solving process to determine the effect on the cognitive regulatory development in gifted and high-achieving learners.

Study participants were selected from this gifted / high-achieving cluster classroom using random replacement sampling. Each participant received the same instructional experiences to adhere to the essence of criterion sampling. The number of participants in the study were determined by the researcher as data saturation began to occur. Data saturation occurs when the researcher finds a pattern in the data or begins to repeatedly hear things from study participants and feels there is not much more to be gained in continuing the research process on additional participants (Marshall & Rossman, 2011).

Data Collection and Procedures

The primary source of data collection in phenomenological research is in-depth interviews (Creswell, 2007). The purpose of the interview process is to provide the participants an opportunity to share the story of how they experienced the phenomena and to help the researcher gain a deep understanding of the lived experiences of the participant (Marshall & Rossman, 2011; Seidman, 2013). Although there is not a defined method for phenomenological interviewing, the interview process should focus on understanding the spirit of the participant's experience with the phenomena, seeking an unbiased understanding of that experience, and culminating the knowledge gained from these experiences to determine the true meaning of the experience (Seidman, 2013).

Phenomenological interviewing involves long, in-depth interviews with the people who have experienced the phenomena (Marshall & Rossman, 2011). The interview process consists of a series of two interviews (Seidman, 2013). The first interview focuses on the participant's past experiences with the phenomena, and the second interview seeks determine the participant's present experience with the phenomena and to join the two interviews together to allow the participant to describe their essential experience with the phenomena.

Researchers choosing a phenomenological method of study also use field notes and observations as secondary sources of data (Marshall & Rossman, 2011). These secondary forms of data can serve as supplemental sources to be used in conjunction with the interviews to supplement the primary data and to serve in data triangulation. Data triangulation is a data collection strategy to help the researcher show the data interpretations are credible and authentic data was collected. Field notes are researcher reflections on the research process along with insights gained during observations. Observations made in the research process can be either formal or informal and provide a procedural method to document behaviors, events, and descriptions of the research environment.

In this study, the researcher chose to implement a pilot study prior to engaging in the research process. Pilot studies are used as a strategy to test out data collection instruments, instructional strategies, data collection methods, and methods of data analysis used in the study (Marshall & Rossman, 2011). This process helps the researcher to refine the process further and get to know themselves as a researcher. During the pilot study, the researcher sought to determine the adequacy of the interview and task protocol to ensure the questions were clear to fifth and sixth grade students and sufficient to answer the research questions.

The primary source of data in this study was derived from participant interviews. Participants engaged in a series of interviews lasting approximately 30-45 minutes. During each interview, the researcher used a semi-structured approach to the interview process by utilizing prepared open-ended questions to assist in guiding the interview process (Patton, 2002). All interviews were transcribed in order to capture the exact wording of the participant (Seidman, 2013). Each written transcript of the interview was labeled with identifying numbers as is a common data collection procedure in qualitative research (Marshall & Rossman, 2011). In reporting the results, the participants were given a pseudonym to protect their anonymity.

Secondary sources of data used in this study consisted of field notes, observations, and student work. Field notes, observations, and student work were gathered throughout the research process beginning in the initial interview phase and continuing until the final interview process. Each of the secondary sources of data were organized, labeled, and coded as suggested through qualitative research data collection procedures (Marshall & Rossman, 2011).

The study began with the researcher engaging in interviews with the study participants on their past and present lived experiences with writing during the mathematical problem-solving process. These interviews occurred in conjunction with non-treatment, in-class research in order to obtain a more detailed and accurate understanding of the participants' prior experiences with writing during the mathematical problem-solving process (Seidman, 2013). The first phase of interviewing occurred while the students engaged in a two-week observation period where they engaged in mathematical problem-solving activities during instruction. Students were asked to solve problems chosen from *Children Are Mathematical Problem Solvers* (Sakshaug, Olson & Olson, 2002). During this phase, writing was not introduced in the mathematical problem-solving process and were only included by personal choice of the students. In addition to the first phase of interviewing, the researcher also engaged in the development of their field notes and observations, as well as, the collection of sample student work.

The next phase of the research process consisted of a two-week period of daily instruction on cognitive regulatory skills and writing strategies used in the mathematical problem-solving process along with application of these strategies. Field notes, observation notes, and student work were also gathered as secondary data throughout this two-week period. In addition, study participants engaged in in-depth interviews in an effort to obtain an understanding of their present experience with the phenomena (Seidman, 2013). After completion of the two-week instruction period, students engaged in a final interview with a focus on obtaining an understanding on their lived experiences of writing during the mathematical problem-solving process as a whole.

Ethical Considerations

Researchers should anticipate ethical issues involved in their research (Creswell, 2007). It is the responsibility of the researcher to be impartial and protect the anonymity of the participants involved. In addition, the research should put safeguards in place to ensure the participants rights, needs, and values are at the forefront of the research process and ensure subjects are not harmed during this process.

Although the researcher does not anticipate any identifiable risks associated with the study, safeguards were put into place to ensure the research will be impartial and the rights, needs, and values of the participants will be ensured. First, the researcher provided the participants and the parents / guardians of the participants with written documentation informing them about the voluntary nature of the study, the research objectives, and data collection procedures. Second, the researcher received written consent forms from the participants and the parents / guardians of the participants prior to the start of the study. Third, to protect the anonymity of the participants, participants were assigned random numbers to be used with any instruments or data collected during the research process. Last, should any participant in the study use English as their second language, the researcher provided a translator or interpreter as needed to ensure language is not a barrier to the participant during the research process.

Data Analysis Procedures

Phenomenological research begins with identifying the phenomenon being investigated (Moustakas, 1994). After collecting the primary and secondary data used to answer the research question, the data was analyzed using Moustakas' suggested phenomenological data analysis procedure. This procedure is comprised of *epoche*, *phenomenological reduction*, *imaginative variation*, and synthesizing the data to determine the essence of the phenomena (Moustakas, 1994; Yüskel & Yildirim, 2015).

The first phase of this analytical process begins with *epoche*. Although *epoche* is a process used throughout the entire analysis process, phenomenologists suggest it as a first phase in phenomenological data analysis (Finlay, 2008; Finlay, 2012; Marshall & Rossman, 2011; Yüskel & Yildirim, 2015). This process begins with the researcher identifying their personal biases and experiences related to the phenomena (Finlay, 2008; Finlay, 2012; Moustakas, 1994;

Marshall & Rossman, 2011). This allows the researcher to bracket their feelings and experiences away from the data and focus on looking at the data collected from a fresh perspective. The researcher provided a complete written description of the phenomenon and read it to reduce researcher subjectivity prior to the start of data analysis (Marshall & Rossman, 2011; Yüskel & Yildirim, 2015).

Phenomenological reduction follows *epoche*. The main purpose of *phenomenological reduction* is the development of textural descriptions of the data (Creswell, 2007; Moustakas, 1994). This reduction process consists of five main steps: horizontalizing, reducing, clustering to create core themes, comparing data sources, and crafting textural descriptions (Moustakas, 1994; Yüskel & Yildirim, 2015). During the horizontalization process, the researcher listed out each piece of data and looked at the data as if each statement had equal value and reduced the data by marking interview data that was not important to the study (Seidman, 2013). Next, the researcher began reducing the data by clustering it into various themes (Moustakas, 1994; Seidman, 2013; Yüskel & Yildirim, 2015). The data were then further organized into core themes which the researcher began to define as the core themes of the experience. The primary data were then compared to other secondary data sources to triangulate or verify the accuracy of the data. Finally, the researcher used the reduced data to write a textural description of the participants' experiences with the phenomena. Using a hermeneutic approach to phenomenological research allowed the researcher to combine their experiences with that of the participant's experiences to derive the textural description of the phenomena (Marshall & Rossman, 2011).

Following *phenomenological reduction*, the researcher used the reduced data to engage in *imaginative variation* (Moustakas, 1994; Yüskel & Yildirim, 2015). The researcher used reduced data from each participant along with their imagination to develop a structural description of the experience. After completing the individual structural analysis, the researcher engaged in the same process for the collective group of participants to develop a composite structure of how the experience occurred. This structure is based on the compilation of both the textural analysis as well as the individual structural analysis of each participant.

The last step in the data analysis process was synthesizing the texture and structural descriptions to derive at the essence of the phenomena (Creswell, 2007; Marshall & Rossman, 2011; Moustakas, 1994; Yüskel & Yildirim, 2015). The researcher created a narrative for each participant on the textural experience and the structural experience providing a description of what occurred and how it occurred (Yüskel & Yildirim, 2015). This information was synthesized to develop a combined, universal description of the experience (Moustakas, Yüskel & Yildirim, 2015).

Summary

This chapter provided a detailed description of the research methodology used in this study. A qualitative methodology was used to examine the cognitive regulatory experiences of gifted and high-achieving students when writing is used as a strategy in the mathematical problem-solving process. Participants in this study were purposefully selected based on a qualitative criterion sampling approach to ensure each participant had the same experience with the phenomena. A hermeneutic phenomenological research approach was used to determine appropriate data collection and data analysis procedures for this study. Ethical considerations were taken into account and addressed throughout the research process.

CHAPTER FOUR: Findings

The purpose of this phenomenological study was to examine the lived experiences of gifted and high-achieving students and their cognitive regulatory practices when implementing writing during the problem-solving process in mathematics in order to develop a conjecture about strategies to increase the academic achievement and growth for these learners. The following research questions helped to develop a framework for this study:

1. How does implementing writing in the mathematical problem-solving process affect the cognitive regulatory experiences of gifted and high-achieving learners?
2. How does implementing writing in the mathematical problem-solving process affect mathematical conceptual understanding of gifted and high-achieving learners?

This chapter presents the findings that emerged from this qualitative study. Twelve gifted and high-achieving students from the fifth and sixth grades were selected to participate in this study using random replacement sampling. Participating students engaged in a two-week pre-treatment period where data was collected in the form of in-depth interviews, observations, and sample student work to help the researcher gain an understanding of the cognitive regulatory skills of the students prior to their experience with the phenomena. Following this two-week period, participants were provided direct instruction on cognitive regulatory skills followed by a two-week treatment period where the students engaged in writing during the problem-solving process. During the treatment period, additional observation and student work samples were gathered. At the end of their experience with the phenomena, students engaged in another extensive interview to gain an understanding of how their experience with the treatment affected their cognitive regulatory skills.

Data was collected from these structured in-depth interviews, observations, and sample student work throughout the months of January and February. Each detailed transcript of the interviews along with observation data and sample student work were labeled with identifying numbers and pseudonyms to protect the anonymity of the participants. The pre- and post-treatment data was analyzed using Moustakas' suggested phenomenological data analysis procedures which includes the following steps: *epoche*, *phenomenological reduction*, *imaginative variation*, and synthesizing the data to determine the essence of the phenomena (Moustakas, 1994; Yüskel & Yildirim, 2015).

The data analysis process began with the researcher bracketing their personal biases and experiences with respect to the phenomena to help the researcher gain a fresh perspective about the phenomena (Finlay, 2008; Finlay, 2012; Moustakas, 1994; Marshall & Rossman, 2011). Next, the researcher engaged in *phenomenological reduction* of the data which includes the following five steps: horizontalizing, reducing, clustering to create core themes, comparing data sources, and crafting textural descriptions (Moustakas, 1994; Yüskel & Yildirim, 2015). Thereafter, the data from each participant was reduced to develop a structural description of the experience known as *imaginative variation*. Finally, the data was synthesized to develop a narrative for each participant to help determine the essence of the participant's experience with the phenomena.

The data analysis process identified five themes and sub-themes related to the effects of writing during the mathematical problem-solving process on the cognitive regulatory development of gifted and high-achieving learners. Each of these themes and sub-themes are described and explained in the following sections.

Theme 1: Achieving Accuracy

Throughout the entire research process, the students' main focus during the problem-solving process was achieving accuracy. Most students referenced this goal throughout each of the planning, monitoring or regulating, and evaluating processes in both the pre- and post-treatment interviews.

Prior to the participants' experience with the phenomena, accuracy was referenced at various times during the problem-solving process. *Lily* described why she read the directions during the planning phase of the task, "I needed to know what to do, so I could get the task right." *Andrew* discussed how accuracy was his intent behind reviewing work: "Yes, because just to make sure I got every little piece correct, because I wanted to get the answers right." Several students described their reasoning behind reflecting on their answers was to ensure their answer was accurate. One of those students, *Lucas*, stated the following when discussing if he reviewed his answers after completing the tasks: "Yes, just to make sure I got the right answer and worked it out good."

Following the implementation of the writing protocol into the problem-solving process, participants continued to suggest that accuracy was an important goal during the completion of the tasks. In fact, several students mentioned how they had been getting more tasks correct since they have been following the task protocol. *Sarah* described how since writing has been implemented during the problem-solving process, she has been getting more answers correct:

> Since we have started writing, I got all the answers right. So I did not really reflect on how I did it, because I got it right. I didn't really think about another way to do it if I got it right. Before I got some of them right, but now I got all of them right.

Andrew originally stated how he reviewed his work to help achieve accuracy. However, after the implementation of the writing protocol, he found himself checking his work more frequently:

> Yes, [I reviewed my work] to make sure the things I thought were correct that were written down. I did this more since we have been writing, because I've been writing down more things. Since the writing sheet has been asking me more things, I have been checking more things.

The review of both *Sarah's* and *Andrew's* work samples also corroborated the fact that they got more tasks correct after her experience with writing.

During both the pre-and post-treatment interviews, participants described how accuracy was an important part of the problem-solving process. Students' interview transcripts along with their student work revealed how after their use of the writing protocol, they got more tasks correct. In addition, some found themselves reviewing their work more because the writing protocol had them write down more things.

Theme 2: Established Self-Regulating Strategies

Students engaged in the problem-solving process were aware of and solicited known self-regulating strategies. The following self-regulating strategies were used by students throughout the problem-solving process both before and after the treatment: (1) re-reading the task; (2) breaking down the task; (3) consulting with others; (4) managing obstacles; (5) reviewing work. However, participants described how their use of these strategies changed when writing became a part of the solution process.

Re-Reading the Task

Most students referenced the use of re-reading the task as a self-regulating strategy during the problem-solving process. Students utilized this strategy to help them better understand the task, ensure their work was accurate, and manage obstacles they encounter during the process. After their experience with the treatment, about half of the students described how they re-read the directions less during the planning phase of problem-solving, while several others stated they re-read the directions more.

During the pre-treatment interview phase, students voiced various reasons for re-reading the task as a strategy to help them maneuver through the problem-solving process. *Isabelle* described how she re-read the task to help her better understand the problem, "…because it is hard to remember them to read them one time." *Jess* stated the reason she re-read the directions was, "because sometimes I wasn't sure, so I went to re-read the directions again."

Students also described how re-reading the task was a strategy used to help ensure accuracy in their problem solving. Many students referenced how they re-read the task to make sure they had the correct numbers and did not miss anything. *Andrew* stated, "[I re-read the task], because I wanted to make sure the numbers I've written down were the numbers that were correct, so I got the right numbers and not the wrong numbers." *Lucas* conveyed he re-read the task during problem-solving, "…just in case I didn't forget anything." *Lily* explained her experience with re-reading and how she re-read the tasks to help her ensure accuracy on supplemental parts of the tasks. She stated how she re-reads the tasks to, "…make sure that I have the right equations and words, so it could help me get part two of the tasks or other parts I might need."

Finally, in the pre-treatment interviews, students expressed how they utilized re-reading the tasks as a self-regulating strategy to manage obstacles they encountered during problem-solving process. Students referenced how re-reading the tasks multiple times helped them to work through a challenging part of the task. *Anna* mentioned, "I just kept reading it and reading it until I understood it." *Jess* stated how, "I re-read it and broke it down. If I did not understand it, I would re-read it again."

After implementing the writing protocol during the problem-solving process, participants described how the writing affected their use of re-reading as a self-regulating strategy. Participants conveyed how the writing influenced their use of re-reading to help them delve into a deeper understanding of the problem and how the frequency of use pertaining to this strategy both increased and decreased after the writing protocol was established.

Andrew mentioned how his use of re-reading changed with the incorporation of writing during problem-solving. Although he used re-reading the task as a self-regulating strategy previously, he described how writing encouraged him to use this strategy to take a closer look at the task and to gain a better understanding of the task: "…it was important to re-read so you got a better understanding…the writing sheet encouraged me to read [the tasks] more, because you have to write more things. So you have to go back and read more." During the first interview, *Andrew* explained how he tried to re-read the additional information provided with the tasks in order to research or learn more about the tasks. He stated, "Yes, [I read the task directions] … not just the directions it said, but like the little bullet points that gave you hints." Writing through the problem solving process created a desire for him to learn more and to extend his research outside the bounds of just the task and its directions, "I read it again and sometimes asked people for a better understanding. I found myself seeking to learn less since we've been writing, because it was more organized."

Much like *Andrew*, *Jess* used re-reading the task as a self-regulating strategy both before and after experiencing the phenomena. However, she expressed how the writing caused her to re-read the task directions less than before the use of writing. She provided details about how the writing impacted her use of this strategy during the planning phase of the task:

> Yes, [I re-read the task] because I wanted to get it right. Maybe it would give me more information sometimes. I found myself re-reading the directions less this week. Because I kind of used the [writing protocol] this week, so it helped me.

Jess reiterated this point later in the interview when asked if she re-read the task during the solution phase of the task. She explained, "Last time I did [re-read the task], but now I did not because the [writing protocol] helped me."

Alternatively, there were other participants who referenced how their use of the re-reading strategy increased after writing. *Steve* explained how prior to the treatment period, he re-read only, "some of them…the ones that I did not understand." After his experience with the treatment, he said, "Since the writing, I have been doing it a little more, because it breaks down what you know. You don't have to do it yourself. It shows you what you need to do next."

When asked if she re-read the tasks prior to the implementation of writing in the problem-solving process, *Viki* commented, "Some of them I did and some of them I did not. Because some of them I did not understand the first time you read them and some of them I did." However, after the writing protocol was established, *Viki* began writing poetry to help her understand the tasks. When asked the same question again, she replied:

> Yes, because like the recent tasks there was something I had to understand from the task. So, I like to re-read the task, since I am trying to do the math. I get a lot of understanding from reading the words. More [since writing], because I don't write poetry about something academic, I usually write it about something silly. When you asked me to write poetry about math, it made me realize that I can get a lot of information from just the words, and I don't have to pay so much attention to the numbers [to gain meaning].

In summary, although students used re-reading as a self-regulating strategy prior to writing during problem-solving, their use of this strategy changed after their experience with the phenomena. Students referenced how re-reading helped them to explore a deeper understanding of the tasks. In addition, students expressed how writing affected how much they used the re-reading strategy. Some participants stated their use of the strategy declined, because their understanding increased. Others reported an increase in the use of the strategy to help deepen their understanding.

Breaking Down the Task

Breaking down the task into smaller pieces was a self-regulating strategy used by the majority of students during the completion of the tasks both before and after the implementation of writing during the problem-solving process. Students tend to use this strategy to help find a more efficient way to solve the tasks and to manage obstacles encountered during the task. Prior to their treatment with the writing protocol, over half of the participants already used breaking down the task as a self-regulating strategy. Yet, of the ones who did not, the majority began using this strategy after the implementation of the writing protocol.

Prior to applying treatment, students referenced how they used breaking down the task to help find a more efficient way to solve the problems. *Lily* stated that, "I broke it up into smaller pieces, so I could see how all the answers could get one big answer." *Jess* described how she, "…broke them down into smaller pieces, so I can easier solve the problem." Students also described how breaking it down helped them focus on one part of the problem at a time. *Anna* explained, "I tried to put [the task] into different parts, so I could focus on one then focus on the next." The student work for each of these participants helped triangulate this finding. *Lily*, *Jess*, and *Anna* all three used the writing protocol to break down their understanding of the task by determining the different skills which could be used to solve the problem, what the problem is asking, and what information is given in the task which might help to solve it. In addition, each of these participants' work showed how they broke down and explained their thinking by using models, equations, and explanations.

When encountering a problem prior to using the writing protocol when completing the task, students also used the break it down strategy. They felt this strategy helped them to get to the correct answer. *Lisa* described how she used this strategy to help her overcome a challenge, "I tried to break it down just a little bit and just tried to put it onto what I knew was there. That kind of helped me point to the right answer." She also described how she used the break it down strategy in a similar fashion to overcome obstacles, "I tried to think around it and tried to break it down and find out what it was."

Some students conveyed how prior to the use of the writing protocol, they viewed the task as a whole. However, their approach changed with their use of writing. During the first interview, *Sarah* stated, "I probably looked at it as a whole as if everything connected somehow, but I did it how one little piece connected to the next." After the treatment, when asked about how she managed the task, *Sarah* explained how her approach changed:

> I think it was more of breaking it down. I did do the writing [protocol], and it helped me break it down. I did that before, but it was a little harder than it is now. Now that I use the [writing protocol], it helps me break it down easier and quicker.

When asked about how she managed the task, *Viki* explained how she first, "…looked at it as one big whole." The use of the writing protocol changed how she managed the task. When asked the same questions in her second interview, she said, "Whatever is in-between [breaking it down and looking at it as a whole]. I didn't take it and break it into small pieces, but I didn't see if as a whole either. I did something in between that." *Clara* had an experience similar to both *Viki* and *Sarah*. Originally, she said, "I can visualize things in my head really easily. It was kind of a part and kind of a whole." Yet, after her experience with the writing, her view of task management changed. She mentioned, "I looked at it as one big whole, but then I broke it down into like thirds." Student work completed by *Clara*, *Viki*, and *Sarah* confirmed their responses. When comparing pre- and post-treatment work, the three participants provided more detailed and organized work during their use of writing.

Although some students used the self-regulating strategy of breaking down the task into small pieces, they explained how writing through the problem-solving process impacted their management of the task. *Andrew* originally said he broke down the tasks prior to the implementation of the phenomena. Yet, in the second interview he described how writing helped him to break the problem down even further. When asked how he managed the task, he explained how he, "[b]roke it down. I broke the tasks down a little more, because the [writing protocol] broke it down into smaller pieces as well." *Steve* described a very different experience. He explained how the use of the writing protocol changed his approach to solving the tasks. He stated, "I thought of them as a whole. I broke them down before. Since, we had that sheet, we did not have to break it down as much. I think that helped me."

Breaking down the tasks into smaller pieces was a self-regulating strategy used by many students during the problem-solving process. Even though several students referenced their use of the break it down strategy prior to their experience with the phenomena, most the students who did not initially use this strategy began using it when writing. Others explained how their use of the strategy changed after the writing. They described how they broke the tasks down even further or used the writing protocol as the strategy for breaking it down.

Consulting with Others

Consulting with others was another self-regulating strategy used by many of the students. During both the pre-treatment and post-treatment interviews, students used this strategy mainly to manage obstacles encountered during problem solving or to gain a better understanding of the task. Even prior to the treatment period, most students used the strategy of consulting with others to regulate their learning. Although, some participants consulted with others less after their experience with the writing protocol because they were able to figure things out on their own.

Pre-treatment interviews with students revealed how several students used the self-regulating strategy of consulting with others to help work through difficulties faced during completion of the tasks. Students consulted with both the instructor as well as their neighbors. *Lucas* explained, "I think on the one yesterday. I think I talked to one of my neighbors, because they were the people around me and seemed like they got it." *Sarah* stated that she consulted with:

> …my neighbor, and I could hear what he said. If he understands something about the problem that I don't understand, I'm going to ask him, because he may understand part of the problem that I don't, and it might help me solve the problem.

Not only did students consult with other students during the pre-treatment phase of the study, observations made during the study indicated how they also consulted with the instructor on multiple occasions before, during, and after completion of the tasks.

Much like breaking down the task, after the treatment phase, participants described how writing affected their use of consulting with others as a self-regulating strategy in different ways. *Andrew* expressed how he conferred with people less after the implementation of the writing protocol. During his second interview, when asked about what he did when he did not understand something, he stated, "I'd ask someone close to me to help me understand something. I found myself consulting with others less since I've been writing, because [with] the [writing protocol] I could really write down on the sheet and not have to ask as many questions."

Originally, *Lisa* only consulted with others to ask clarifying questions. She stated, "At first when you said we could use 20 blocks, I asked …how many blocks we were supposed to use?" After her use of writing during the problem-solving process, she began using consulting with others less. When asked if she asked questions of others, she replied, "yes," but then went on to explain why she consulted with others less since her use of the writing protocol. *Lisa* said, "Less since we've been writing, because whenever you put your words on the sheet it kind of helps you think deeper, and it is easier for you to answer the problem."

Chris originally mentioned how he, "just talked to others about how much it did not make sense." After his experience with the writing protocol, he said although he continued to consult with others, he did it, "a bit less [since the writing protocol].".

Observations made by the researcher during the study also confirmed how students consulted with others less after their experience with the phenomena. Prior to writing, students consulted with the researcher-instructor on multiple occasions whereas they consulted with the researcher-instructor and others less.

Both before and after the treatment, students consulted with others through the problem-solving process. However, after their experience with writing during the problem-solving process, students reported a reduction in the use of this strategy because of an increase in the understanding of the tasks.

Managing Obstacles

When asked about how the students manage obstacles during the problem solving process, a large percentage of participants described the use of more strategic and purposeful strategies after the implementation of writing. Prior to her use of writing, *Sarah* explained how she tried or played with the numbers to overcome an obstacle. However, after treatment, her strategies for managing obstacles included more specific, deliberate efforts. In her first interview, *Sarah* described her experience with managing obstacles encountered during the problem solving process as: "I didn't give up, but I probably tried once after that. Then, I looked back on my work and thought this is zero percent right or correct." *Sarah* also described how before the use of writing she played with the numbers to see if she could find an answer:

> I would ask questions, and if I did not understand after that, I would try to take numbers and see what I could do with those numbers that would relate to the problem. If that didn't work, I would ask myself what am I doing?

After the implementation of the writing protocol, her strategies became more intentional and calculated:

> I asked questions. I think I read the problem again, and then I would look back over my work to see if I added or calculated something wrong, and if I didn't, I would probably ask [my neighbor]. If that did not work, I would probably raise my hand and tell you I did not understand.

In addition, she reported, "I would re-read it again, and I would think of another way to solve it instead of trying to re-solve it. I would try to solve it another way by changing this or changing this."

Andrew described a similar experience. At first, *Andrew* relied on himself to think about other ways to overcome an obstacle prior to his experience with the phenomena. He stated, "I tried to keep thinking of other ways possible to figure out the answers." After his experience with the phenomena, his repertoire of strategies to overcome obstacles increased. He stated, "I asked somebody who had a better understanding of the problem to help guide me through. I did it sometimes before we started writing. Now, I did it on a little bit of the problems."

Isabelle's ability to manage obstacles during problem-solving also became more deliberate. Prior to implementing writing in the problem-solving process, *Isabelle* used the "skip it and come back" strategy when she encountered a problem. She stated, "I would try to solve the main task first, then I would go back to that to see if I could then solve it." After the implementation of the writing protocol, *Isabelle* used more strategic methods to help when she encounters obstacles during problem solving. She explained:

> I would either ask you a question about how to do it, or I would find another way to solve it…I have not really encountered an issue since we have been writing. Since I have been writing, I have been getting them right. I have not encountered any problems since I have been writing.

Lisa described how writing impacted her thought process when encountering problems. She said, "I would either try to work around it or try another way…[W]henever I wrote in words, it kind of helped me think deeper, so I could think of more ways to solve the problem."

Anna originally stated her process for managing obstacles during problem solving was, "I tried to put it into different parts, so I could focus on one then focus on the next." Afterwards, she described a deeper, more intentional strategy for managing obstacles, "I would stop and analyze the problem and go back and see if there was anything earlier on in the problem itself to help me fix the problem."

Chris initially described his strategy for overcoming issues in problem-solving as, "I tried something else." Following his experience with the writing protocol, his repertoire of strategies became more diverse and descript. He said:

> I would go back over what I had done. If I found a problem, I would go back over and do it again to see if I could get it right. If I didn't see a problem, I would ask someone else if they came across the same problem.

Previously when *Viki* encountered problems, she said, "I thought about it until I understood it." She would also, "…change how I was doing it. I have trouble starting over completely, because I forget how I started. When I do start over, I get it wrong five or six times completely before I actually get it right." After her experience with the writing, she described more strategic thinking as well as problem-solving strategies. She stated, "Well, I thought through it and broke it up into pieces. I thought about what does this piece mean and what does this piece mean. Then, I went back and put it back together to help me understand." In addition, she said:

> I took what I did, and I took what I had right and what I had wrong and asked what does it mean individually. Then, I would look at it and try to figure out what I did wrong and fix it. Most of the time that would fix it. Sometimes I would have to do it over and over again, but most of the time, I got there.

Clara described her initial strategy when she encountered a problem was "…I persevered and kept on…." Subsequently, she started using multiple strategies and focused her efforts on comprehension. She stated, "I read the problem over and over again to comprehend the problem in my head. When, I kind of got it, I worked it out. Then, I started on it from there."

A few students not only experienced the use of more strategic problem-solving strategies but also encountered fewer problems while completing the tasks. When *Steve* described his initial method for managing obstacles during problem solving, it was nondescript and unintentional. He stated, "I would just make sure there was nothing else to do, I guess." After his experience with the treatment, he mentioned a specific strategy and explained how he did not confront as many problems. He said, "I just asked for help or I just tried on my own. I encountered fewer problems since we have been writing." *Lily* explained how at first, "I would just go over it and find my mistakes and use those mistakes to help me next time to make sure I get it right." Then, she explained how, "I slow down and try to read my paper. If I couldn't find what I was supposed to do next, I would ask my neighbor for help or ask you for help. [I've experienced] less problems [since we've been writing]."

Student work also paralleled these findings. Many students wrote notes on their work samples prior to their use of the writing protocol about being confused and not understanding the problems, and their attempts at solving the problems appeared to stop there. However, in their completion of the writing protocol, several students expressed how they encountered little to no problems.

Students expressed how writing impacted the way they overcame problems during the tasks. After their experience with writing during the problem-solving process, students portrayed how their approach to managing obstacles became more planned and varied. Participants also reported encountering fewer problems during the tasks than prior to their use of writing.

Reviewing Work

Students used the self-regulating strategy of reviewing their work during the problem-solving process. Half of the students increased their use of the evaluating strategy of reviewing their work to help them through problem-solving. Some participants even explained how the writing itself became a strategy to help students review their work.

Sarah described how writing became a way of reviewing her work. During her first interview, she explained, "I would go back over everything I did, so that the next thing I did had the correct numbers and equations as I did before." After her experience with the treatment, when asked if she reviewed her work, she answered:

> Well, yeah, because I did not work it all out on the sheet that you gave us. I would work it out either in my head or in the folder. Then, I would like take it on the sheet, and it was kind of like me re-writing it to think about it again.

During her first interview, *Anna* answered when asked the question if she reviewed her work, "No, not really." Yet after she had been using the writing protocol, she replied, "Yes, because on the beginning part if I did something there, it might relate to something later."

Viki's original response was: "No, I just kept going." Once she had gained experience with writing during the problem-solving process, her answer changed to, "Yes, I do that a lot when I write. So, I did that a lot. I think it helps me get the problem correct and faster."

Lily conveyed in her first interview how she did not review her work during problem-solving. She said, "No, because I thought I could get the right answer without reviewing it then getting the final answer and then going back to review it." When answering the same questions in her second interview, she replied, "Yes, because if I thought that if I were review the task from what I had done previously, it would help me figure out what I need to do next…sometimes."

Reviewing work was a strategy used by many students throughout problem solving. However, students referenced how their use of reviewing their work increased after their experience with writing during the problem-solving process. Some even explained how the writing itself served as a tool to help them review their work as they worked through the task.

Theme 3: Consideration and Awareness

Prior to the treatment, student participants experienced an overall lack of consideration and awareness of certain cognitive regulatory skills. Although, after their experience with the writing protocol, students described how they considered and became more aware of these cognitive regulatory strategies. Students expressed this consideration and awareness in relation to several aspects of cognitive regulation. These aspects include: (1) establishing goals for the task; (2) making connections to prior learning; (3) applying / extending their learning.

Establishing Goals for the Task

During the first interview, most students expressed how they did not consider setting any goals related to the task. The second interview along with student work samples indicated that the vast majority of the participants began the process of learning to establish goals when completing the tasks.

Sarah expressed how she began setting more goals for the tasks. Prior to her experience with the treatment, when asked if she set any personal goals, she answered, “Definitely not. I was not thinking about that.” After the introduction of the writing protocol, when asked the same question, *Sarah* stated, “Yeah, because one of the things on the sheet said to make a goal, but it wasn't really a personal goal. It was like how to understand something or find an entrance point.”

Andrew described how writing made him more aware of the goal setting process. Prior to instituting writing into problem solving, when asked if *Andrew* set any personal goals, he replied, “No, I don't really know.” After the phenomena, he commented, “Yes…The writing sheet encouraged me to do this more, because it was more organized.”

When asked about setting goals, *Lucas* originally stated, “No, I don't know.” After writing, he began setting explicit goals related to the tasks at hand. During his second interview, he explained his goal setting process: “Mainly they were getting it right and one of them was like making a good model that other people could understand.”

Viki's answer when initially asked about making personal goas was, "No, because I don't know. I didn't really care to make a personal goal. The math problems I wanted to get done really fast whether I got the answer right or wrong." Yet, post-treatment, her answer changed to:

> Yes, because I know when I make goals and stuff, it makes me want to achieve it. When I started realizing that I can look at the math outside the numbers, I realized that it can help me do the math better. I did not do this before the writing.

In the beginning, *Lily* discussed how the establishment of goals was not something she thought about. She said, "…I didn't really think about doing that." In her post-treatment interview, she stated, "Yes, because whenever I was trying to solve the tasks, I said to myself, 'Can I make a goal that will help me?'"

The student work samples resulted in a similar outcome. Not only did the students begin developing goals after their use of the writing protocol, as their familiarity of the writing increased, their goals became more deliberate and situational. Students' work samples indicated how their goals went from goals relating to accuracy to goals about finding patterns and attempting new models.

Making Connections to Prior Learning

Students also expressed a general lack of consideration and awareness during the pre-treatment interviews when it came to making connections to prior learning. Of the participants interviewed, only one student, *Lisa*, expressed how they made a connection to any prior learning or any prior task they have completed. Yet, most students became more aware of potential connections to prior learning after the implementation of writing during the problem-solving process.

Andrew described how his awareness of making connections became more evident after his experience with writing. During the first interview, *Andrew* did not make any connections with any prior tasks or problems. However, after the establishment of the writing protocol, when asked if he made any connections, he replied:

> Yes, I related the How Much Film task to the one we did today. Since I had already did that task, it helped me with the better understanding of the task I did today. I tried to make connection a little bit more since we have been writing, because these tasks I finally understood.

Prior to implementing writing, *Lucas* explained how he made, “no” connections to prior learning or other tasks. However, after using the writing protocol, he explained, “Yes, it helped because the problems were like kind of they talked about them a little bit, the same, it is hard to explain.”

Steve originally replied when asked if he made connections, “Not that I can think of.” After his use of the writing protocol, he described a very different experience: “Yes, the ‘Code it Be’ task and the ‘Snowman.’ Making that connection helped me solve that one easier. I made more connections last week with the [writing protocol].”

During his first interview, *Chris* said he did not make any connections with prior learning or previous tasks. In his post-treatment interview, he stated:

> Yes, the one with the snowmen seemed a lot like it with the one where we had to make a 3-digit code. Like the one with the 3-digit code, we made a diagram to see how many combinations we could make. We could also do this with the snowmen.

Just like many of her peers, *Viki's* pre-treatment experience with solving the tasks did not involve making connections to prior learning or previous tasks. Once she started writing, she began making connections to other disciplines to help her during problem-solving. She described this as, "So, I did…But those are math problems, and I related them to stories that I have written or read. I thought about the patterns in the story and related them to the patterns in the problem."

Much like establishing goals, students' work samples and researcher observations indicated how students began making connections to prior tasks and previous learning after their use of the writing protocol. Initially after starting the writing protocol, very few students made connections. However, as their experience with writing increased, so did their ability to make connections to prior learning. Observations also revealed how students verbally made connections more throughout with the use of the writing protocol.

Applying / Extending Learning

Prior to any specific discussion on cognitive regulatory skills, most students expressed a lack of consideration or awareness on evaluating, applying, or extending their learning from the task. When asked if the students reflected upon their learning from the task, over half of the students responded with, "No" or "I don't know."

Before her experience with the phenomena, when asked if she evaluated her answer, *Jess* explained, "Yes, because I compared them, and I saw that it was right." She merely compared her answer to the answer for the task. After her experience with writing, she evaluated her answer in an effort to deepen her learning. When asked the same question during her second interview, *Jess* replied, "I reviewed my solution and tried to do it another way to see if I could get the same answer…I would not have done that before [the writing protocol]."

When answering if she applied and extended her work and her learning, *Anna* originally indicated, “A little bit, because maybe the way I was thinking of was harder than what I came up with at that time.” The post-treatment interview revealed how *Anna* began evaluating her work more. She stated:

> The paper sort of forced you to because it had a question on it. So, yes, I did. I couldn't write something down that didn't have anything to do with the problem. So, I would have to think about it for a second.

Steve was one of the participants who considered applying the skills gained from the task. His initial response when asked if he evaluated his learning was, “Yes, so I could remember how to do something, so I could learn it.” However, after the use of the writing protocol, he explained how the writing required him to make a conscious effort to assess his understanding and knowledge. When asked the same question during the second interview, he stated, “Yes, because one of the questions on the sheet was did you look back and think and find something you learned. The writing affected me doing this.” He also described how he would try to discover other ways to solve the task when he was finished. He indicated, “…I was just sitting around. So, I would have something else to work on. I did not do that before we started writing.”

Viki explained how in the beginning she did not try to apply or extend her learning from the tasks. The writing protocol changed her outlook on her application of learning. In her second interview, when asked if she evaluated her learning, she replied:

> Yes, because I kind of feel like if you do it and let it skid across your mind, then when you came across the same thing, it can help you. A lot of people don't do this. I like to do this a lot.

She also explained how after her experience with the phenomena, she would think about other ways to solve the problem, which she did not previously do. She said, "When, I finished I did think about other ways that I could have solved it. I never actually did it, but I did ponder ways that I could do it."

Isabelle also described how the writing protocol helped bring awareness to the possibility of other ways of solving the tasks. It helped push her thinking into other directions. She said, "When the [writing protocol] told me there were more ways that you could do it, I tried to think about other ways. Sometimes I couldn't and sometimes I could."

Both student work samples and researcher observations corroborated the increased use of applying and extending learning with the use of the writing protocol. Several students denoted in their work samples how they began thinking about how they could use the knowledge gained in other ways, such as the use of manipulatives or models, and how they could extend what they learned to other work in the classroom. In addition, researcher observations during the use of the writing protocol indicated the students' desire to apply and extend their learning to multiple areas such as the use of manipulatives to solve the tasks.

A general lack of consideration and awareness was reported by many students prior to their experience with the phenomena regarding three areas of cognitive regulation: goal setting, connections, and applying and extending the learning. After their use of the writing protocol, most students expressed an increased attention, awareness and use of each of these strategies while completing the tasks.

Theme 4: Self-Efficacy

Several participants described a change in their self-efficacy as it relates to problem-solving after their use of the writing protocol. Most students described their feelings about their performance in a more positive manner after their experience with the phenomena.

Sarah mentioned how since the implementation of writing in problem-solving, her accuracy has increased and her feelings about the tasks have been more positive:

> Before I felt ok. I think I feel better when I did get it correct, because I think it my mind that I got it right. Before [the writing], I was getting them wrong, so I didn't feel so good. After [the writing], I felt pretty good since I got them right.

Andrew's self-efficacy increased through the use of writing during the problem-solving process. He described his emotions prior to the use of writing as, "Good some of the time. Sometimes I felt like in the beginning I felt good, but then towards the middle and end I started feeling not so good knowing my answer is not working that well." Afterwards, he described a more positive experience, "I felt pretty good throughout the tasks. Yes, the writing helped me feel more confident! Because, it took question and cut it into smaller pieces. It was really simple to do that rather than take it on full."

Prior to her use of writing, *Lisa* described how she "…felt a little stressed [at first]. In the middle, I felt kind of good because I was getting it. At the end I felt proud." Yet, she expressed more positive feelings once she began using the writing protocol during the problem-solving process. She said, "The words made me a better problem solver just because it helps you dig a little deeper. I felt better since we've been writing."

When asked about his feelings related to the completion of the tasks, *Steve* originally said:

> Some of them I felt good and some of them not so well. The doubling bread and there was one other one, it was not because of their complexity, but more because of some questions I had, but I got them at the end.

Yet, he described his post-treatment emotions in a more positive light. He stated:

> I think on last week I did a little bit better, because we have done them more and some of them are similar, so it is easier to know what it is asking. Yes, the writing helped me feel a little better about it, because I just like writing the words better than modeling the equations.

Chris explained how the writing impacted his overall feelings about his performance. He described his experience as:

> Actually to me it didn't seem like it was a lot easier [last week], but it really was easier to me. I wasn't having to flip the page back and forth to go over things. I had already written it down. I did not have to stop as much as I did before. I did not have to go back as much. I would [originally] have to go back to the page as much. When we started writing, I did not have to go back to the page as much unless I wrote down some information that wasn't right. Yeah, it helped my thinking process. Well, it helped me think a lot better.

Viki explained how not only her outlook on problem-solving improved, but also her attitude about math also improved. She said:

> Well, before I stopped liking math. Until like 4th grade, everything was super easy, and I didn't have to do anything. When I hit 5th grade, everything was so hard. I was so lost. I got to feeling like I wasn't good enough. Everyone else was already having to sit in class and learn it, but I didn't have to try. So, I just started

> thinking about how I was bad at math. So, then, my teacher was telling me to tell myself that I do like math. Yes [the writing has helped me feel better].

Some students explained how their self-efficacy was originally tied to the complexity of the tasks being solved. *Clara* expressed her experience as:

> The first one, it was kind of like a no-brainer. The second one was hard, so I don't think it was explained correctly. The bread one I did not get at all. The film one I got. My emotions changed depending upon the difficulty of the task.

After her experience with the writing, she explained how her attitude toward the whole problem-solving process improved. She stated:

> When we started writing, I was not as tired, and sleepy and bored to death. Yes, I felt better because I thought, maybe I can actually get this because I was not bored out of my mind. When we started writing, I thought this is different. Maybe I should give it a try. Maybe I might be good at it.

Lily described a somewhat different experience with a similar outcome. She initially felt, "Good on all of them." After her experience with the writing protocol, she explained how although she felt the writing made things more difficult, her feelings related to her performance still improved. She said:

> Whenever we didn't have the sheet, I thought it was a little easier than without the sheet because you could go out of order, and you did not have to do into a specific order like the sheet asked. I felt like I performed better when I was writing [though].

Positive self-efficacy was also signified in the student work and during researcher observations. Several students referenced in their writing protocol how their feelings about their performance was positive. In addition, observations suggested how frustration levels decreased after the implementation of writing during the problem-solving process, especially with the students who struggled finding entrance points prior to writing (*Andrew*, *Lisa*, *Clara*).

Even though some students expressed positive self-efficacy prior to their experience with the writing protocol, many students described their problem-solving process in a more positive light after writing. Some students even reported an increase in their overall self-efficacy about math after their experience with the writing.

Theme 5: Conceptual Understanding

Most students described how their conceptual understanding of the tasks increased with the implementation of writing during the problem-solving process. This change was communicated through the participants' greater use of multiple solution strategies, improved understanding of the task, and enhanced strategic analysis of possible solution strategies.

Greater Use of Multiple Solution Strategies

The vast majority of students expressed how they found themselves considering more solution strategies after the use of the writing protocol.

Prior to her experience with the treatment, *Sarah* limited her learning to only considering one or two ways to solve the tasks. When asked about considering multiple solution paths to solve the tasks, *Sarah* replied, "Yesterday – two ways. The first way and the second way." After the implementing the writing, she explained how her conceptual understanding was extended to now include models, which they did not before:

> The first one I did for both of them an equation, but for the next problems I did all three of them. I don't like drawing models, but I found myself drawing more models with the [writing protocol]. I had the answers when I drew a model. I had the explanation and the equation before I drew the models, but the models kind of went off those.

Sarah also explained how writing has affected her conceptual understanding of the problems. Her understanding of the problems increased and with that she was able to model more of the problems. She stated:

> I could focus on what the problem was actually asking me more than like the other stuff that didn't really have anything to do with the problem. Well, [the writing] kind of helped. It helped me to understand what I understood when it wanted you to draw a model and explain it.

Andrew explained how he only "sometimes" drew models to help him solve the problems prior to the use of the writing protocol. However, afterwards he stated, "Yes. I found myself doing this more since I've been writing, because it helped me more to understand than last time, because it didn't really and now [the writing protocol] has been asking."

Isabelle described how she used models as a strategy to help solve the tasks even before the implementation of writing during the problem-solving process. When asked if she ever used a diagram, illustration, or a model, she replied, "Yes. On the first one, because I think everyone did on the first one. Also on the dough, film, and the stairs tasks." However, even her use of models increased with the use of the writing protocol. When asked the same question during the second interview, she answered:

> Yes, a lot. It helps me. The models and stuff really help me. If I usually have it in my mind, it helps me. I think I found myself doing it more with the writing [protocol], because it has the box for the model box, so it helped me think about drawing models more.

Originally, *Andrew* stated how he, "… just thought about one way" to solve the tasks. After the implementation of the phenomena, he described how his experience with the writing changed this:

> One, sometimes two. I mostly did equations and models, and I wanted them both to match. I knew that the equation would help, but the model would help me more to have a visual. I considered more ways this week than prior to writing. Because, the [writing protocol] asked every time we got the sheet for an equation, model, and explanation. The [writing protocol] made me more aware.

Isabelle's experience was much like *Andrew's*. She described how she originally only used one strategy until a suggestion was made by the instructor. In her first interview, she said, "On the film one. That was the only one I did two different ways. I did the different ways because of a suggestion you made." After her experience with the phenomena, she indicated how she considered and analyzed more solution strategies. She stated:

> Usually I do it depending it on what is easier. On the last one I did with the squares, I drew the model. If I can do a model, I usually just do a model, and if I do the math [equations], I just do the math. At the same time, I know there are other ways to solve it.

Many students described how the use of writing helped them to express their understanding of the task in multiple ways. When asked if they considered multiple methods of solving the tasks, several participants explained how prior to the treatment they only considered one or two ways. After their experience with the phenomena, the same students explained how they thought of more possible solution strategies in different ways.

Before the implementation of the writing protocol, *Anna* said, "I usually focused on one thing, and I stayed on that one thing longer than needed, I think." Once writing was used during the problem-solving process, she considered, "One or two. Like I would think to [solve the task] with models and pictures, and I would think of one to do with numbers and equations."

Lucas explained how he thought about, "[t]wo or three" strategies. After his experience with the writing protocol, he mentioned how he used, "Probably one or two. Yeah, [the writing] just gave me more ways to work out the problem, see it differently, or find other ways to work it out."

Steve said that before the writing protocol he used, "At least one, maybe two. Depending upon the task. If I couldn't get it the way I was going to do it, I would try a different way." Yet, after implementing writing into the problem-solving process, he stated:

> I think of at least one and maybe two. I think I thought of more ways using writing, because you could solve it as models, equations, or words. So, if you asked us one way, we could show a different way if someone already had that one.

When asked if he ever considered changing his solution strategies during problem solving, *Steve* initially said, "No, ma'am." After the use of writing, he found himself thinking about the possibility of using other strategies to solve the tasks. His reply to the same question was, "Yes, just to see if I could get it another way. [T]he writing impacted that, because I could do it two ways and not just one."

Clara described a similar experience. At first, she, "… only got one" way to solve the problem. However, she explained how she considered more solution strategies after the implementation of the writing protocol and how she felt writing impacted this change, "My majority was two. More when we did the writing. I think the writing was helping us by putting all of our thoughts on paper."

Viki, a high-achieving student who does not like math, only considered, "[o]ne way" to solve the problem at first. After her experience with writing, something she was comfortable with, she thought about:

> [l]ike four or three. Not too many, but not none. Yes, [I felt like I considered more ways when writing]. I started relating writing to math. I thought of how you can take poetry and make it apply to math. I took something complex to me and applied something I understood and made it simple.

Lily stated how she, "…had one way" prior to writing. Afterwards, she, "…thought about a few different ways. Whenever I was solving the tasks I said, is this the right way that I should do it or should I look for another way to find the answer."

Work samples further confirmed how students implemented a greater number of solution strategies when solving the tasks when writing was used in problem-solving. Many students' work samples denoted how students thought about a variety of skills which could be beneficial to complete the tasks and how they solved the tasks in a multitude of ways. About half of the students attempted to solve the problems using two or more different solution strategies when using the writing protocol.

Improved Understanding

Although most of the students expressed an increase in the use of solution strategies, a few students stated how they considered fewer solution strategies, because the writing protocol helped them to think deeper about the problem initially. When originally asked if she used multiple solutions strategies, *Sarah* originally stated, “Yes, because yesterday there was a second way we thought you could do it. It only got to a certain number, so it changed but then it changed back.” After instruction of cognitive regulation and implementation of the writing protocol, when asked the same question she answered:

> Before we learned what cognitive regulation was, yes, I looked back, and I changed what I did. However, as I used the [writing protocol], it was like my way of double-checking, so now, no I don't think I did that.

Sarah described how the use of the writing protocol helped her to better think through the process. When asked about the consideration of multiple solution strategies during the planning process, *Sarah* explained, “Before starting it? Ummm…maybe, like I might have thought about it, but I wouldn’t have taken it as seriously as when I started it.” After writing, she described her experience as:

> I usually just thought of a way that I could do it, if that way worked for me, I might think of another way, but most of the time if that way worked, I just used that way. The writing [protocol] kind of helped me think through the process of what I was doing.

Jess also described a similar experience as *Sarah*. Prior to implementing writing into the problem-solving process, *Jess* found herself changing strategies during her solution of the task. When asked about the use of multiple strategies, she explained, “… I started doing the wrong thing, so I changed for the next question." After implementing writing into the problem-solving process, she found that she got the tasks correct more often, thus, not requiring her to change her strategy in the middle of solving the task. When asked the same question during the post-treatment interview, she answered, "No, because when I did the first path I got it right. I found myself getting them more right this week."

Improved understanding of the tasks was evident in the student work samples. Prior to the implementation of writing, several students struggled with finding an entrance point to begin the tasks, and some students had no work for the tasks. However, after writing was implemented, the vast majority of the students were able to at least find an entrance point to the tasks. In addition, understanding and execution of the tasks seemed to increase more for the participants who answers were more detailed and thorough (*Andrew*, *Sarah*, *Viki*). For the students whose replies on the writing protocol were not as deep, the work samples showed less understanding of the task through fewer questions answered and less use of multiple strategies.

Enhanced Strategic Analysis

A large percentage of participants said their analysis of potential solution strategies deepened after their experience with the phenomena.

Andrew explained how he was more intent in his strategic analysis of the solution strategies he chose when solving the tasks after writing was implemented. He explained, "I chose the simplest solution strategy and the one I knew the most. I analyzed probably a little more since we've been writing, because the [writing protocol] made you write more."

Isabelle stated that the writing did help her when analyzing the various ways to solve the task. She mentioned:

> No, I usually kept it with just one way. Because it is easier for me to just think one way, so I don't get confused. Because I try to think of the easiest way first. [The writing] did kind of impact that because I did have to write out my thoughts.

When asked if he analyzed strategies, *Steve* said, “[n]o” at first. Yet, afterwards his experience with writing, he replied:

> Yes, like on the one where we have to divide like two for each day, I was thinking, I wasn't really sure, if I could divide by four for every two days. I analyzed more with the writing. I don't know why. I just did it more.

When initially asked about evaluating strategies during problem-solving, *Lily* said, “No. I'm not sure.” After her experience with the treatment, she said, “Yes, because I thought that it would give me a different answer, and if I got the same answer as last time, I would keep trying to find different patterns and ways to get to the solution.”

Viki explained how she did not analyze possible strategies at first. She said, “No, because I only did one way.” Yet, after being subjected to the treatment, she stated:

> I chose the path I chose because it was the most logical way to solve it. I thought this was not about what was easiest for me, but it was about what was the best way to get through the problem and solving it.

As the students’ experience with the writing increased, the work samples displayed more strategic analysis. After their use of the writing protocol, students referenced how they analyzed possible solution strategies with respect to how reasonable the strategy was with respect to the task, to how easy the strategy was for them, or to how likely the strategy would be able to help them get the correct answer.

Students portrayed a deeper conceptual understanding of the tasks after the implementation of the writing protocol. Participants reported the consideration of multiple solution paths, a more profound understanding of the task, and a more strategic analysis of possible solution strategies.

Summary

The purpose of this hermeneutic phenomenological study was to explore the lived experiences of high-achieving and gifted students and their cognitive regulatory functions when writing was incorporated into the mathematical problem-solving process. Data was collected and triangulated through the use of individual interviews, student work samples, and classroom observations. A total of 12 students from the fifth and sixth grades participated in the study consisting of two identified gifted students and 10 high-achieving students. The participants provided details about their experiences with the writing and its impact on their cognitive regulatory functions.

Five themes evolved from the analysis of the data collected throughout this study. These themes include: (1) achieving accuracy, (2) established self-regulating strategies, (3) consideration and awareness, (4) self-efficacy, and (5) conceptual understanding. A summary of the themes and subthemes are presented in Table 1. These themes help to develop an understanding of the impact writing in mathematical problem-solving has on the cognitive regulatory abilities of gifted and high-achieving learners. Chapter 5 will discuss the findings in relation to the research questions for this study, any potential classroom implications related to this study, and the recommendations for further research.

Table 1: Themes & Sub-Themes

Theme	Sub-themes
1. Achieving Accuracy	
2. Established Self-Regulating Strategies	a. Re-reading the Task b. Breaking Down the Task c. Consulting with Others d. Managing Obstacles e. Reviewing Work
3. Consideration and Awareness	a. Establishing Goals b. Making Connections c. Applying & Extending Learning
4. Self-Efficacy	
5. Conceptual Understanding	a. Greater Use of Multiple Solution Strategies b. Improved Understanding c. Enhanced Strategic Analysis

CHAPTER FIVE: Discussion

Chapter 5 provides a discussion about the findings presented in Chapter 4 to help reveal the lived experiences of gifted and high-achieving students' cognitive regulatory development when writing is implemented into the mathematical problem-solving process. Five themes were outlined in Chapter 4 to help capture the essences of these experiences. These themes include: achieving accuracy, established self-regulating strategies, consideration and awareness, self-efficacy, and conceptual understanding. This chapter is divided into three main sections to discuss the findings of this study. The first section of this chapter focuses on the research questions presented in Chapter 1 and how the findings relate to each of these research questions. The second section discusses how the findings can influence current classroom practices. The third sections addresses recommendations for future research.

Responses to the Research Questions

This section presents responses to the research questions. The research questions that guided this study are as follows:

1. How does implementing writing in the mathematical problem-solving process affect the cognitive regulatory experiences of gifted and high-achieving learners?
2. How does implementing writing in the mathematical problem-solving process affect mathematical conceptual understanding of gifted and high-achieving learners?

Each of the research questions is presented below along with a discussion of how the findings presented in this study relate to each question.

Research Question #1: How does implementing writing in the mathematical problem-solving process affect the cognitive regulatory experiences of gifted and high-achieving learners?

Cognitive regulation comprises the skills necessary to manage cognitive tasks (Cross & Paris, 1988; Paris et al., 1983). Aspects of cognitive regulation include planning, monitoring or regulating, and evaluating (Cross & Paris, 1988; Paris et al., 1983; Schraw et al., 2006; Weinstein & Mayer, 1986). This discussion below includes how the findings from this study relate to each of these aspects.

Planning. There are several strategies which relate to the planning component of cognitive regulation examined during this study. These strategies include re-reading the task, establishing goals, developing a plan, considering multiple solution strategies, and analyzing possible solution strategies (Hartford Community College Learning Center, 2014). Previous research studies indicate that gifted and high-achieving students are typically good at the planning and organization portion of cognitive management (Yildiz, Baltaci, & Güven, 2011; Ablard & Lipschultz, 1988).

Re-reading the task. The findings revealed that all students re-read the task in some form prior to the implementation of the writing protocol. However, after their experience with the writing, a few students (*Viki*, *Andrew*, *Clara*, *Steve*) described re-reading the directions of the task more at the beginning of the tasks. *Steve* explained how the writing helped him to break down the task even more which required him to have to re-read the directions more. Yet, many students (*Lisa*, *Anna*, *Sarah*, *Jess*, *Lily*, *Isabelle*, *Chris*), including both identified gifted students, reported how they re-read the task less during the planning phase because the writing helped them gain a better understanding of the problem. *Sarah* described how writing helped her to make more meaning from the tasks and understand them better. *Jess* explained how the writing protocol helped her work the problem better, which caused her to write less. Thus, based on this study, it appears the effects on re-reading the task is inconsistent. What is consistent, however, is that the writing protocol helped students understand the task better whether they utilized the re-reading strategy more or less. These results coincide with the previous research studies which provide how writing can help students better understand what the problem is asking (McCormick, 2010; Kuzle, 2013).

Establishing goals. During the pre-treatment interview, only two students (*Jess*, *Chris*) alluded to establishing any goals during the planning phase of the task. Most students referenced a general lack of awareness or consideration related to the establishment of a goal. After receiving direct instruction on cognitive regulation along with the use of the writing protocol, all students confirmed their development of a goal during the problem-solving process even if the goal was merely to get the answer correct. *Andrew* explained how the writing encouraged him to establish more goals, because the protocol was more organized. *Lily* said that when writing through the problem-solving process, she found herself trying to set goals to help her through the completion of the tasks. *Viki* stated how she realized when she created goals, it pushed her to try to achieve those goals throughout problem-solving. Student work samples provided additional support to substantiate this claim. The work samples indicated how students not only created goals after their experience with writing, but also as their use of the writing increased, the goals became more deliberate and intentional with respect to the task. Accordingly, it seems the direct instruction of cognitive regulatory skills along with the use of the writing protocol helped students to become more aware of establishing goals. This finding further confirms prior research that states how direct instruction of metacognitive skills to both gifted and high-achieving students increases the students' use of those skills (Alexander & Schwanenflugel, 1996; Jaušovec, 1994; Mok et al., 1996; Tan & Garces-Bascal, 2013; (Lioe, Ho & Hedberg, 2005; Mevarech & Kramarski, 1997; Kramarski, Mevarech & Arami, 2002).

Developing a plan. The data revealed that all but one participant (*Viki*) made plans prior to the implementation of writing. These findings corroborate previous research that indicates gifted students are good at planning (Yildiz, Baltaci & Güven, 2011) and high-achieving students use their knowledge management skills during the problem-solving process (Arslan & Akin, 2014; Lawson & Chinnappan, 1994). The post-treatment findings indicate no significant change with the use of writing during the problem-solving process. Both before and after treatment, students described how they thought about how they would solve the tasks while they were reading the tasks.

Considering multiple solution strategies. During the first interview, only one student (*Jess*) referenced the consideration of more than one or two possible solution strategies. Although after receiving direct instruction on cognitive regulatory skills along with the use of writing during the problem-solving process, all but three participants (*Jess*, *Lucas*, *Steve*) reported an increase in the number of solution strategies they considered during the planning phase of completing the task. *Sarah* found herself using more models through the use of writing even though she did not like making models. *Andrew* said he considered more ways to approach the problem through the use of writing. *Lucas* considered more ways to work the tasks out and solve them differently. Classroom observation and student work helped to triangulate this finding. Not only did students display a wider variety of solution strategies and skills, but students also executed the tasks in more ways than they did prior to their use of the writing protocol. Therefore, the use of the writing protocol influenced both gifted and high-achieving students to consider more solution strategies. This finding is concurs with previous studies that provide how writing can help students identify additional strategies to solve problems (McCormick, 2010; Kuzle, 2013).

Analyzing possible solution strategies. Prior to writing, the majority of the participants (*Lisa*, *Sarah*, *Viki*, *Jess*, *Clara*, *Lily*, *Steve*, *Chris*) did not analyze multiple solution strategies either because they only considered one way or just did not compare the strategies they considered. Of the few participants who did report the comparison (*Andrew*, *Lucas*, *Isabelle*), they described how they chose the strategy that was easiest and best for them. These initial findings authenticate previous research that states how gifted and high-achieving students tend to struggle with the cognitive regulatory skills of choosing the best strategy to effectively and efficiently complete the task (Anderson, 1990; Bandura, 1993; Kramarksi, Mevarech & Lieberman, 2001; Carr et al., 1996; Alexander & Schwanenflugel, 1996).

After the participants' instruction on cognitive regulation and use of writing, all participants with the exception of two (*Jess*, *Isabelle*) analyzed multiple strategies prior to starting the task. In addition to analyzing multiple strategies, student analysis became more intentional and strategic. *Steve* said he analyzed his options more using the writing. *Sarah* explained how the writing helped her think through each step and consider which option would be best for her. *Viki* said she would think about her options and choose the one that was the most logical way for her to solve it accurately. Student work samples also showed how students increased their analysis of multiple strategies to consider their reasonableness, ease of use, and likelihood to obtain an accurate solution. Hence, students described how the use of the writing protocol helped students to analyze multiple strategies when problem solving and their analyzing of those strategies became more intentional and purposeful. These results add to the findings from several prior studies which state how writing can help students evaluate and determine the benefits of multiple strategies (McCormick, 2010; Kuzle, 2013; Van der Stel et al., 2010), analyze and evaluate mathematical concepts (McCaster & Betts, 2007; Lynch & Bolyard, 2012), and emphasize strategic thinking (Whitin & Whitin, 2010).

Monitoring or regulating. Strategies involved with monitoring or regulating through the problem-solving process include breaking down the task; using models, diagrams, illustrations, and charts; making connections; reviewing work; consulting with others; and managing obstacles (Hartford Community College Learning Center, 2014).

Breaking down the task. Prior to their experience with the phenomena, just over half of the participants (*Lisa*, *Anna*, *Andrew*, *Jess*, *Lucas*, *Lily*, *Chris*) broke down the tasks at least part of the time. After their experience with the writing, more students (*Lisa*, *Anna*, *Sarah*, *Viki*, *Andrew*, *Jess*, *Lucas*, *Clara*, *Lily*, *Chris*) reported their use of breaking the task down to help them manage the completion of the task. Even those who reported breaking down the tasks before (*Andrew*, *Jess*), reported how the use of the writing protocol helped them to break it down even more. *Sarah* explained how the use of writing helped her to break down the task easier and faster. *Andrew* also described how he felt he broke it down even more with the writing, because the writing protocol broke it down as well. Student work samples also demonstrated how the students exhibited breaking down of the tasks through the identification of different skills to solve the task, what the task was asking, and what facts are provided in the task. These samples also displayed more detailed student work when the writing protocol was used. Based on these findings, it seems that students tend to break down the tasks even further with the use of writing during the problem-solving process.

Models, diagrams, illustrations, and charts. In the first interview, only three students (*Viki*, *Lucas*, *Isabelle*) reported modeling more than just on task that are visually related. After their experience with the writing, most of the students (*Lisa*, *Sarah*, *Andrew*, *Jess*, *Lucas*, *Lily*, *Steve*, *Isabelle*, *Chris*) described how their use of models, diagrams, illustrations, or charts to help them solve the tasks increased. *Andrew* expressed how his use of models, diagrams, illustrations, and charts increased when writing, because writing through problem-solving helped him to gain a better understanding of the tasks. *Isabelle* described how although she used models prior to the writing on several tasks, she found herself using them more with the writing merely, because the writing protocol helped he become more aware of the possibility of a model. Therefore, when students incorporate a writing protocol into the problem-solving process that suggests the use of models, diagrams, illustrations, and charts, their use of such strategies tend to increase.

Making connections. Prior to the instruction on cognitive regulation and experience with the writing, only one student (*Clara*) attempted to make a connection with any previous learning or any other tasks. Even *Clara* only reported making a connection with one of the tasks during the pre-treatment period. Students expressed a lack of consideration or awareness in regards to making connections.

After the treatment, all the participants with the exception of three (*Lisa*, *Anna*, *Sarah*) described making connections to prior learning and previously completed tasks. *Andrew* and *Steve* both made connections to prior tasks they had completed and explained how these connections helped them understand the tasks better and solve them easier. Both classroom observations and student work samples upheld these findings. Students made several remarks in class about connections with the tasks, and their responses on the writing protocol indicate the awareness of connections increased as the experience with the writing protocol increased. As such, the results show how the direct instruction of connections, along with the reference to such skills in the writing protocol, help students to increase their use of this cognitive regulatory skill.

This finding supports earlier research that indicates how writing can help to establish connections to prior learning (Card, 1998; Schudmak, 2014; Mills et al., 1996) and how direct instruction of metacognitive skills can improve the use of those skills (Alexander & Schwanenflugel, 1996; Jaušovec, 1994; Mok et al., 1996; Tan & Garces-Bascal, 2013; Lioe, Ho & Hedberg, 2005; Mevarech & Kramarski, 1997; Kramarski, Mevarech & Arami, 2002).

Reviewing work. Prior to their experience with the phenomena, most students (*Lisa*, *Sarah*, *Andrew*, *Lucas*, *Clara*, *Steve*, *Isabelle*, *Chris*) exhibited the use of reviewing work to help them monitor and regulate through the problem-solving process. During the second interview, all students with the exception of one (*Jess*) described how their use of this strategy increased while completing the tasks. Along with the increase of the number of students using this strategy, the ones who originally reported the use of the strategy pre-treatment (*Anna*, *Sarah*, *Jess*, *Clara*) reported how the use of writing helped them to review their work more. Students reported how the writing became a mechanism to help them review work more. *Sarah* explained how simply the act of writing helped her think about it again and again which aided in her review of the work. *Andrew* found himself checking his work more just because he was writing more information down. Thus, gifted and high-achieving students provided how the use of writing attributed to an increased review of their work.

Consulting with others. All but two students (*Anna*, *Isabelle*) discussed how they consulted with others during the problem-solving process prior to their use of writing. Yet, after the use of the writing protocol, four of the students who originally consulted with others (*Lisa*, *Andrew*, *Jess*, *Chris*) reported using this strategy less due to an increased understanding of the task. *Lisa* stated how she did not consult with as many people, because putting her words on paper helped her think about the problem deeper, and it was easier to understand. *Andrew* explained how writing helped him make better sense of the problem which led him to not need as much help from others. *Jess* described how she did not need to consult with others, because she had not encountered any problems since the institution of the writing protocol. Classroom observations substantiated these results. Students asked more questions of the researcher-instructor prior to their experience with the phenomena than after. Therefore, it seems that due to a deeper understanding of the task through the use of writing during problem-solving, consulting with others decreased.

Managing Obstacles. The data revealed how participants only used one or two unplanned strategies to manage obstacles or figure out something they did not understand prior to their experience with the writing. However, almost all of the students with the exception of *Anna* and *Jess* described an increased use of various strategies to overcome problems during the tasks. The data provided evidence of how these strategies were also more intentional and strategic. Of the students who did not report this increase use of strategies to overcome obstacles, they reported a better understanding along with encountering of fewer problems. When *Lisa* encountered a problem or something she did not understand, she would think around the problem and try to solve it another way. *Lily* slowed down her work, re-read the problem again, and asked for help. Even with the awareness of all these strategies, she found herself encountering fewer problems. *Isabelle* would ask questions or find another way to solve the tasks. She also reported encountering fewer problems, because she got more of the tasks correct since the implementation of the writing protocol. Student work samples supported that the students encountered fewer problems. Prior to treatment, several students indicated confusion on their work samples. After treatment, students indicated in their writing protocol how they encountered fewer problems. So, writing encouraged gifted and high-achieving students to find more ways to manage obstacles encountered during problem-solving and their efforts became more purposeful and deliberate. These findings further solidify prior research stating how writing can help students explore other options when difficulties are encountered, emphasize strategic thinking, and understand the problem better (Schoenfeld, 1982; Whitin & Whitin, 2010; McCormick, 2010; Kuzle, 2013).

Evaluating. Students evaluate after the completion of the task and includes: reflecting on answers and solution strategies used during the task, applying and extending the learning obtained during the task, and the feelings evoked during the task (Hartford Community College Learning Center, 2014).

Reflecting on answers and solution strategies. In the initial interview, the participants described how all but one of them (*Viki*) reflected on their answers but only to determine if they were accurate in their findings. These results are much akin to the previous research stating that gifted students struggle with evaluating their work (Yildiz, Baltaci, & Güven, 2011). After their experience with the writing, only about half of the students (*Anna*, *Jess*, *Clara*, *Lily*, *Isabelle*) reflected on their answers. However, these students reported a deeper purpose for reviewing their answers such as reflecting on potential solution strategies which could be more effective and efficient. Students described how their consideration of other possible solution strategies were more strategic in their analysis. Since her use of writing, *Anna* thought about shorter ways to solve the problems after completing the tasks. *Jess* pondered other ways she could solve the tasks. *Chris* found himself writing down more ways he could go about solving the problems once we had reviewed the answers. Although fewer students reflected upon their answers and evaluated their work, the students who did report evaluation of their work elicited deeper thinking during this process. These findings support previous research stating how writing helps students to revise and reflect on their work and reflect on how to solve a problem and why the process worked (Mills et al., 1996; McCormick, 2010; Kuzle, 2013). In addition, it also corroborates the research which states that writing will help students will focus on the process and not just the answers (Whitin & Whitin, 2000).

Applying and extending learning. The initial interviews revealed how most students (*Lisa*, *Anna*, *Viki*, *Andrew*, *Lucas*¸ *Lily*, *Isabelle*) did not consider to evaluate their learning on a task to apply or extend their learning to other areas. The data revealed how post-treatment, most students began becoming aware of evaluating their learning and extending their learning to new areas. *Viki* described how it is important to understand what you learned from a task, so that when you come across a similar problem in the future, you would know how to approach it. *Steve* explained how the writing forced him to consider his learning and how he might extend it or apply it. He felt he would not have thought about this before the writing. Classroom observations and student work samples confirmed how students applied and extended their learning to the use of multiple strategies, such as models and manipulatives, and the consideration of how to extend the learning to the classroom. Consequently, during this study writing influenced students to apply and extend their learning more than before. Prior research stating that writing helps students to reflect on their personal mathematical understanding helps to back up this finding (Whitin & Whitin, 2000).

Self-efficacy. The data showed that prior to incorporating writing into the problem-solving process, only four students (*Andrew*, *Jess*, *Lucas*, *Lily*) expressed any positive emotions related to their performance on the tasks, and only *Lily* communicated that she felt, “good on all of them.” After some time using writing during problem-solving, all but two students (*Lucas*, *Isabelle*) stated how they felt an increase in their self-efficacy when it came to solving mathematical tasks. *Lisa* said the use of writing helped her to think deeper about the problem which led to her having more positive emotions about her abilities as a problem-solver. *Sarah* expressed how her self-efficacy improved since she has been writing, because she has been getting the tasks correct since she has been writing. *Andrew* enthusiastically stated how the writing helped him feel more confident about his abilities, because it broke down the problem in a more manageable way. *Viki* described how not only did the writing help her feel better as a problem-solver, but it also helped her to improve her self-efficacy in math. Classroom observations revealed a decreased level of frustration, especially related to those students who initially struggled with finding an entrance point to the task. In addition, student work samples referenced positive feelings related to personal student performance on the tasks during their use of the writing protocol. Accordingly, students overwhelmingly described how the use of writing had positive influence on their self-efficacy as it pertains to mathematical problem-solving.

Research Question #2: How does implementing writing in the mathematical problem-solving process affect mathematical conceptual understanding of gifted and high-achieving learners?

The National Council of Teachers of Mathematics (2000) and NAEP (2003) define mathematical conceptual understanding as a student's capability to think about mathematical problems by using connections to prior learning, mathematical concepts, and various representations. This understanding can be exhibited through a student's use of models, diagrams, charts, or illustrations, as well as, the application of mathematical principles and definitions and the recognition and appropriate use of signs and symbols. For the purposes of this study, the following aspects of conceptual understanding were examined: making connections to prior learning; using models, diagrams, charts, or illustrations during problem solving; and identifying multiple solution strategies for effective problem solving.

Making connections. As referenced above, most students did not make any connections prior to their experience with the writing protocol. Making connections to prior learning or previously completed tasks was not something they remembered doing. However, after using writing during the problem solving process, the results changed. All but three of the students (*Lisa*, *Anna*, *Sarah*) made connections during the problem-solving process. Students described how making connections helped them to understand the problem better and derive an answer easier.

Through the direct instruction of cognitive regulatory skills such as making connections and using writing as a tool to help focus students on this skill, students became more cognizant of making connections during problem-solving and incorporated them more thus contributing to mathematical conceptual understanding. These findings substantiate previous studies which indicate how direct instruction of metacognitive skills, such as making connections, can improve the use of those skills (Alexander & Schwanenflugel, 1996; Jauśovec, 1994; Mok et al., 1996; Tan & Garces-Bascal, 2013; Lioe, Ho & Hedberg, 2005; Mevarech & Kramarski, 1997; Kramarski, Mevarech & Arami, 2002), and how writing can help students to establish connections to prior learning (Card, 1998; Schudmak, 2014; Mills et al., 1996).

Using models, diagrams, charts, and illustrations. Prior to their experience with writing, only a few students (*Viki*, *Lucas*, *Isabelle*) used models, diagrams, charts, or illustrations during problem-solving outside of visually related tasks. Participants described how they did not like to draw models during problem solving and how, if they did try, it was difficult to figure out an accurate model. Yet, after using the writing protocol during the treatment period, most students (*Lisa*, *Sarah*, *Andrew*, *Jess*, *Lucas*, *Lily*, *Steve*, *Isabelle*, *Chris*) described how they used models, diagrams, charts, and illustrations more during problem-solving. Students explained how with the writing they found themselves making more models – even the students who expressed how they did not like using models in math. In addition, students described how the use of models helped them to understand the problem better. By using models, diagrams, charts, and illustrations and other solution strategies fluidly and flexibly during problem-solving, students exhibit a deeper grasp of the problem and the mathematical concepts behind it (National Council of Teachers of Mathematics, 2000).

Identifying multiple solution strategies. Before the incorporation of writing into problem solving, the majority of the students described only identified one or two strategies which could be used to solve a given task. A large percentage of these students only considered a second strategy when their first strategy failed. After the treatment period, all but three students (*Jess*, *Lucas*, *Steve*) reported an increase in the number of solution strategies identified which could be used to complete the tasks. Several students alluded to how the writing protocol helped them to become cognizant of other possible ways to solve a problem. In addition, students also mentioned how they not only considered multiple strategies to solve the problem, but also found themselves looking for other ways to solve problems during the problem-solving process and after the completion of the task. This supports prior research that states how the act of writing during math helps the students identify additional strategies (McCormick, 2010; Kuzle, 2013).

Thus, of the three aspects of mathematical conceptual understanding considered in this study, findings show how students use of these skills all increased after direct instruction of cognitive regulatory skills and the use of writing during the problem-solving process for the majority of the study participants.

The Overall Development of Cognitive Regulatory Skills & Mathematical Conceptual Understanding

Individual review of student work samples led to a broad finding related to the overall development of cognitive regulatory skills and mathematical conceptual understanding. When analyzing each of the participants' interview responses and work samples individually, it was evident the students who provided more strategic and thorough responses on the writing protocol, exhibited a greater development of cognitive regulatory skills and deeper mathematical conceptual understanding. On the contrary, students whose responses on the writing protocol were low-level, indicated a reduced development of cognitive regulatory skills and less of an increase of mathematical conceptual understanding. Thus, student effort in their responses on the writing protocol had a direct relationship on the development of cognitive regulatory skills and mathematical conceptual understanding.

Implications of the Findings on Classroom Practices

The findings of this study have several implications for classroom teachers of gifted and high-achieving students seeking to positively impact their mathematics instruction. Because this study worked to reveal the overall experience of gifted and high-achieving students when writing was integrated into the problem-solving process, the insights provided from these experiences may be able to help instructors to develop teaching practices to aide in furthering the academic achievement and growth of gifted and high-achieving learners. The essence of these experiences are the basis for my recommendations described below.

The knowledge gained from this study added detail to previously established findings about the importance of direct instruction of metacognitive skills. Prior research provided how direct instruction of metacognitive skills can aide in the development and use of those skills in gifted and high-achieving learners (Alexander & Schwanenflugel, 1996; Jauśovec, 1994; Mok et al., 1996; Tan & Garces-Bascal, 2013; Lioe, Ho & Hedberg, 2005; Mevarech & Kramarski, 1997; Kramarski, Mevarech & Arami, 2002). However, this study focuses solely on the development of cognitive regulatory skills. In a similar fashion, the findings showed how direct instruction of specific cognitive regulatory skills can impact a students' use of such skills. Based on these results, instructors need to teach gifted and high-achieving students openly about cognitive regulation, what skills and / or strategies help to aid in the development of cognitive regulation, and how cognitive regulation will impact their learning.

In addition to explicitly teaching gifted and high-achieving students about cognitive regulation, this study clearly identified certain aspects of cognitive regulation that increased when writing was implemented during the problem-solving process. The data collected revealed a strong relationship between the increased use of already established self-regulating strategies and the use of a writing protocol during problem-solving. By developing a writing protocol for gifted and high-achieving learners, certain cognitive regulatory skills, such as breaking down the tasks, managing obstacles, and reviewing work, which students may be already utilizing may be a strategy to further advance these skills.

Several skills increased simply because of the awareness realized by students through the use of writing the during problem-solving process. The act of writing itself helped the students become aware of these skills and consideration of their use. These skills include establishing goals relating to the task, making connections to prior learning or other tasks, and applying and extending learning. The act of writing in mathematics itself helps students become more aware of things (Pugalee, 2001) and previous studies show how writing helps students to make connections (Card, 1998; Schudmak, 2014; Mills et al., 1996).

Finally, the findings from this study suggest that direct instruction on cognitive regulatory skills in conjunction with the use of structured writing to address those skills can increase the mathematical conceptual understanding of gifted and high-achieving learners (Alexander & Schwanenflugel, 1996; Jaušovec, 1994; Mok et al., 1996; Tan & Garces-Bascal, 2013; Lioe, Ho & Hedberg, 2005; Mevarech & Kramarski, 1997; Kramarski, Mevarech & Arami, 2002). Teachers seeking to deepen the mathematical conceptual understanding of gifted and high-achieving students should provide direct instruction on cognitive regulatory skills in conjunction with establishing a structured writing protocol for use during mathematical problem-solving. The participants described how the instruction of cognitive regulation and the use of a writing during problem solving directly coincided with the increased use of skills attributable to mathematical conceptual understanding such as making connections; using models, diagrams, illustrations, and charts; and identifying multiple solution strategies.

Recommendations for Future Research

Although gifted and high-achieving learners tend to perform well with academic achievement, these students were not making the mark with respect to academic growth (Kaufman, 1976; Clark, 2013; Camilli, 2008; Johnsen 2014; Loveless et al., 2008; Plucker, 2015; Sanders & Horn, 1998; Spielhagen, 2012). This study sought to find a way to help further the academic growth of gifted and high-achieving learners. Because metacognition is an important aspect in the learning process (Flavell, 1979; Perkins, 1995) and both gifted and high-achieving learners fall short with certain aspect of cognitive regulation (Alexander & Schwanenflugel, 1996; Anderson, 1990; Bandura, 1993; Frye, 1989; Kramarski, Mevarech, & Lieberman, 2001), this study searched to determine if using writing in math could be a strategy to help increase students' metacognitive abilities and, in turn, their academic growth.

This study focused on understanding the lived experiences of gifted and high-achieving students when writing is implemented into the mathematical problem-solving process. Future research should be conducted to determine if the increased use of cognitive regulatory skills cause an increase in the academic growth in gifted and high-achieving. These findings from this study suggest that writing during the mathematical problem-solving process does have a positive impact on mathematical conceptual understanding. However, the question remains does this increase in mathematical conceptual understanding translate to an increase in mathematical achievement and growth.

This study concentrated on the use of writing to build cognitive regulatory skills in mathematical problem-solving. However, it would be interesting to determine if this finding holds true with other subject areas. Thus, further research should be completed to determine if writing can serve as a strategy to improve cognitive regulatory skills and deepen conceptual understanding in other subject areas.

During this study, the researcher found how the participants' use of cognitive regulatory skills varied. Because of the importance of differentiated instruction for gifted and high-achieving students, the researcher recommends further research to determine the impact of differentiated instruction of cognitive regulation along with the development of differentiated writing protocols for each student on the development of cognitive regulatory skills and academic growth. It would be interesting to explore and analyze individual learning profiles with respect to cognitive regulatory development to see if it has any impact on the results.

The participants of this study were gifted and high-achieving students. Both groups of participants in this study described how writing during the mathematical problem-solving process positively impacted their development of certain cognitive regulatory skills. Discovering the impact of a similar study on low-achieving and average-achieving students would help to further this investigation.

Additionally, the time frame of this study involved a two-week pre-treatment period followed by a two-week post-treatment period. The limited time frame could impact the results of the study. As such, the researcher suggests additional future research that extends the treatment period over an extended period of time to determine if determine if similar results occur.

Summary

The purpose of this study was to determine the impact of writing during the mathematical problem-solving process on the cognitive regulatory development of gifted and high-achieving learners. This study used a hermeneutic phenomenological approach to explore the lived experiences of the study participants in relationship with the phenomena. Data were collected through intensive student interviews, teacher observations, and sample student work and analyzed to derive at the essential themes of the experience. The data suggests that the use of writing during the problem-solving process positively impacts both the development of cognitive regulatory skills and mathematical conceptual understanding in gifted and high-achieving learners.

The results of this study were examined to determine implications on current teaching practices and to develop further recommendations for future research. Implications of findings on classroom practices include the direct instruction of cognitive regulatory skills to further cognitive regulatory development in gifted and high-achieving learners and the establishment of a writing protocol that focuses on cognitive regulatory skill development to further already developed skills along with developing an awareness of typically unemployed skills. The insights gained from this study also served to develop a conjecture on which to recommend future research. Recommendations for future research include exploring the impact of writing during the mathematical problem-solving process with gifted and high-achieving students on mathematical achievement and growth, determining if the same findings hold true when writing is incorporated in other academic subject areas, examining if differentiated cognitive regulatory instruction and writing protocol development can deepen the cognitive regulatory skills of gifted and high-achieving learners even further, investigating the impact of writing during the mathematical problem-solving process on the cognitive regulatory development of low-achieving and average-achieving students, and, due to the time limitations of this study, extending the time period of treatment to determine if similar results occur.

In summary, the findings of this study do not directly answer the question of whether writing can be utilized as a strategy to aid in the development of cognitive regulatory skills in gifted and high-achieving learners which, in turn, will positively impact the academic achievement and growth of such learners. However, it does serve as a conjecture to inform future research which could provide more concrete evidence to support if writing is a tool which can be used to help advance gifted and high-achieving learners.

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APPENDICES

APPENDIX A: Informed Consent Form

APPENDIX A

Informed Consent Form

Title of Study: A Phenomenological Review of the Effects of Writing During Mathematical Problem-Solving on Cognitive Regulatory Skills in Gifted and High-Achieving Learners

Investigator: Heather M. Knox, a graduate student in the Carson-Newman University Department of Education

You are being asked to participate in a research study to gather information for use in a dissertation research project. Your signed consent is necessary for your participation in this project.

The Informed Consent Form provides you with a basic explanation of the purpose of the project, the duration of the project, the procedures to be used in the project, along with the possible risks and potential benefits related to your participation in the project. Please review this document carefully and ask the investigator about any additional questions you may have. If you still wish to be a part of this project, please sign on the last page of this document.

Purpose: The purpose of this research is to determine the effects writing during the problem-solving process in mathematics has on the development of cognitive regulatory skills and mathematical conceptual understanding in gifted learners.

Duration: The duration of this project will be approximately four weeks.

Procedures: A group of students will engage in mathematical problem-solving activities during the duration of the research. During the first two weeks, students will be asked to complete these activities using their personal mathematical problem-solving strategies. Two times during this initial two-week period, the study participants will engage in personal interviews with the investigator regarding the problem-solving strategies used. The last two weeks will consist of intentional instruction on metacognition and cognitive regulatory strategies as well as the use of a series of questions designed to target cognitive regulation skills. Study participants will engage in personal interviews with the investigator regarding the problem-solving strategies used along with how the questions affected their performance.

Possible Risks: There are no known risks associated with the participation in the study.

Potential Benefits: Gifted and high-achieving learners may increase cognitive regulatory skills and mathematical conceptual understanding. Additionally, findings may benefit future gifted and high-achieving students by contributing to the field of gifted and high-achieving education.

Confidentiality: Measures will be put into place to help ensure the confidentiality of your participation in the study. Student information will be kept in a secured, locked area during the duration of the study and for three years following the completion of the study. All information relating to students who participated in the study will use pseudonyms to protect the identity of the students. The results of this study may be published and/or presented without naming the students as subjects.

Voluntary Participation: Participation in this project is voluntary. Refusal to participate in this study will have no effect on any services provided to you. You are free to withdraw from this study at any time without penalty by contacting the investigator.

Contact Information: If you have any questions or concerns regarding this study, please contact Heather Knox at hmknox@cn.edu.

By signing below, you acknowledge you have either read this document or have had it read to you. You have been given the opportunity to ask the investigator questions regarding this study and are voluntarily willing to participate in this study. You will be given a copy of this consent form with your signature.

____ ______________

Signature of the Parent / Participant Date

____

Printed Name of the Parent / Participant

____ ______________

Signature of the Investigator Date

APPENDIX B: Task Questions to Enhance Cognitive Regulation

APPENDIX B

Task Questions to Enhance Cognitive Regulation

Before Completion of the Task: Planning

1. What goals would you like to achieve in completing this task?
2. Did you read the instructions thoroughly prior to starting the task?
3. What questions did you ask yourself prior to starting the task?
4. How can you effectively organize your time in order to complete the task and achieve your goals?
5. What are the different skills and/or strategies you can use to complete the task?
6. Do you need to research or learn more about something before you begin? If so, what do you plan to research or learn more about? How do you plan to go about your research?
7. Of the different skills you know or have learned about, which one will be the most effective and most accurate in completing the task?

During Completion of the Task: Managing Information

8. What important information is provided in the task or the task directions?
9. How can you break the task down into smaller pieces?
10. Did you slow down when you encountered a problem during completing the task? What problem did you encounter?
11. Can you relate this task to other tasks you have encountered before? If so, which ones?
12. Draw a picture, illustration, or diagram of what the task is asking you to accomplish.

During Completion of the Task: Understanding the Task

13. Did you continuously ask yourself if you are achieving your goals during the completion of the task?

14. What different alternatives did you consider prior to selecting a solution path and an answer?
15. Why did you choose the solution path you chose?
16. How many times did you review your work to ensure your solution path will achieve your goals and the completion of the task at hand?

During Completion of the Task: Encountering Problems

17. How many times did you stop and re-read parts of the task to ensure your understanding?
18. Did you change your solution strategy when the strategy got confusing or you felt there was a more efficient and effective way to complete the task?
19. Did you ask others for help when you did not understand something? If so, when?

After Completion of the Task: Evaluation

20. Did you ask yourself if there was an easier way to complete the task? Did you discover an easier strategy? If so, what was the strategy?
21. Did you reflect the answer or your initial goals after completing the task?
22. What were all the solution strategy options you considered when completing the task?
23. After completing the task, what did you learn?
24. How did you feel about your performance before, during, and after completion of the task? Which parts were easy? Which parts were difficult?

Reference: Hartford Community College Learning Center (2014). Metacognitive Awareness Inventory. https://www.harford.edu/~/media/PDF/Student-Services/Tutoring/Metacognition%20Awareness%20Inventory.ashx

APPENDIX C: Interview Protocol

APPENDIX C

Interview Protocol

1. Did you read the directions of the task before starting? Why or why not?
2. Did you make any goals prior to starting on the task? Why or why not?
3. Did you make a plan before starting this task? If so, what plan did you make?
4. Did your plan change throughout the completion of the task? If so, why did you change your plan?
5. How many different ways did you consider in completing the task?
6. Did you research or seek to learn more about the task before starting it? If so, what did you seek to learn?
7. Did you analyze different ways to complete the task prior to starting? If so, how many? What did you consider when deciding on a solution path?
8. How did you manage the task during completing it? Did you break it down into smaller tasks or see it as one task?
9. What did you do when you came to a piece of information you did not understand?
10. Did you draw an illustration, picture, or diagram in solving the task?
11. Did you relate this task to other tasks you have completed previously? If so, which ones? How did you use that experience to help you in solving this task?
12. Did you review your work during the completion of the task? Why or why not?
13. What did you do when you encountered a problem in the task?
14. Did you consult with others when you encountered a problem or something you did not understand? Why or why not?

15. Did you ever stop and re-read the task during the completion of the task? Why or why not?
16. Did you change your solution strategy or consider other solution strategies after you started on the task? Why or why not? Did you like your new strategy better?
17. Did you reflect on your answer or your solution strategy after completing the task? Why or why not?
18. Did you reflect on your learning after you completed the task? Why or why not?
19. How did you feel about your performance before, during, and after the completion of the task?