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Effects of implementation of the Next Generation Science Standards on the math performance of 5th grade students with ADHD

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EFFECTS OF IMPLEMENTATION OF THE NEXT GENERATION SCIENCE STANDARDS ON THE MATH PERFORMANCE OF 5TH GRADE STUDENTS WITH ADHD

By

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Dedications

This thesis is dedicated to my wife Julie, who has given me the support, encouragement, and tough love I needed to succeed in graduate school. It is also dedicated to my daughter Avery, whose love and silliness helped make this tough journey a little less stressful.

This thesis is also dedicated to my parents, Robert and Virginia Zimmer. Their willingness to not give up on me during my challenging years as an undergrad helped shape my dedication and motivation not only as a student and worker, but also as a parent.

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I would also like to thank Mansfield Township Elementary School especially the students who took part in the study. My passion for the study was heightened by my student's passion and willingness to learning. They truly are an inspiration to me as my journey continues.

Abstract

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The purpose of this study was to implement two components of the Next Generation Science Standards, gathering and reasoning, into the 5th grade math curriculum for students diagnosed with ADHD. Each student completed a 21st Century pre-assessment created by the My Math Text book (McGraw Hill, 2011) and modified by the instructor. This assessment contained 10 questions that were a culmination of the concepts that were covered in the upcoming chapter. A total of 8 students participated in the study. Of these, 4 were taught with the components of gathering and reasoning, while the rest of the 4 were involved in traditional instruction without these components. A pre-and post control group design was used in the study. The results indicated that the students learning with the components of gathering and reasoning gained slightly higher scores on the post-assessment compared to those without the components of gathering and reasoning. It seems that the components of gathering and reasoning did not have a major impact on student math scores, however using the components, students were more engaged and enjoyed in learning new concepts. Further research is recommended to determine if the components of gathering and reasoning would have a long-term effect on students with ADHD and their math performance.

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Chapter 1

Introduction

According to the Center for Disease Control and Prevention (CDC) Attention Deficit/Hyperactivity Disorder (ADHD) is one of the most common neurodevelopmental disorders of childhood (CDC, 2016).

Students who have been diagnosed with ADHD may have difficulty sustaining their attention during class taught with a traditional method of teaching. Unlike students without attention difficulties, they may have difficulty grasping the concepts and skills necessary for success. They may lose focus, missing the important skills necessary to be successful. Some students may even have disruptive behavior.

Components of the Next Generation Science Standards (NGSS) may alleviate the difficulties students with ADHD endure with traditional math curriculum, therefore increasing math skills leading to increased assessment.

The traditional and conventional mathematics curriculum is based on procedural knowledge, such as memorizing operations with little regard to underlying meanings or a sense of why students are using the operations, instead of developing conceptual and strategic knowledge in students (Montague, Warger, & Morgan, 2000). When compared to other countries, students from the United States perform below expectations in the subject areas of math and science. Students are feeling the pressure to perform in school not only against their peers, but also against those in other countries. In response, the Next Generation Science committee decided to take the international benchmarking approach to improve science curriculum. The committee focused their approach based on the success of those countries who perform on a high-level year after year. From here, adaptations have been made to our science curriculum to mimic those high performing countries. For example, there is now more emphasis on the physical science standards, such as chemistry and physics content while life science standards will now focus on human biology and relationships among living things that highlights the personal and social significance of life science. Other adaptations include; using unifying ideas to provide focus and coherence, providing multiple examples to make expectations for students concrete and transparent, and finally making meaningful connections to assessment to maintain focus on raising student achievement (NGSS, 2016).

The traditional math curriculum may cause difficulties for students with ADHD due to the processes and delivery of the content. According to Keath Low, "Breakdowns in the learning process can occur in several areas including memory, attention, problem solving and organizing -- all areas that can be challenging for students with ADHD" (Low, 2016). Traditional math curriculum is based on the aspects of memory, attention, problem solving, and organization. When students first begin learning math lessons, the majority of the content is based on memorization and being able to maintain focus. When these areas are weak, students with ADHD will often lack the foundation for math concepts and since math concepts build off each other, this will lead to more difficulties down the road. The NGSS may be helpful because the components of gathering and reasoning provide students with a more hands on, student driven, approach where they are able to manipulate tools to figure out content on their pace. The teacher acts more as a facilitator, compared to the traditional methods where students are sitting, trying to maintain focus, and the teacher directs the majority of the lesson.

In this study, I implemented two components of the Next Generation Science Standards, gathering and reasoning, into the 5th grade math curriculum for students diagnosed with ADHD. The gathering component of NGSS when implemented involved the students in asking questions, obtaining and evaluating information, planning and carrying out investigations, using models to gather data and information, analyzing data, and using mathematics and computational thinking (NJACE Science Education Institute, 2015). The purpose of Gathering and Reasoning in the math setting is to allow the students to take control of their learning through the aspects mentioned above.

The research question that was examined by this study is: Can 5th grade students diagnosed with ADHD use the components of Gathering and Reasoning from the Next Generation Science Standards to increase their math skills?

I hypothesized that students with ADHD who use the two components will perform better on math 21st century pre-assessments and post-assessments than other students with ADHD who receive the traditional approach to teaching math. Through a year's worth of training which detailed the processes, implementations, experimentation, data analysis, and planning of the NGSS I have seen what the Next Generation Science Standards can truly be and how they have impacted the students not only in a way that has made them more involved in their education, but has also motivated them to learn.

So why not implement the strategies into the math curriculum where instruction and student expectations have been changed year after year with almost the same results?

Science and math have been universally linked for years. They both require students to analyze the physical world. Both content areas rely on a similar problem-solving approach and tools such as observation, comparison, measurement, and communication. Even some big ideas are the same: change (function), systems, and classification (Gurganus, Janas, & Schmitt, 1995). Students with ADHD typically have trouble maintaining focus during tradition lessons. This could lead to the inability to obtain the skills necessary to solve mathematical problems, resulting with learning gaps and with assessments below their peers.

The relationship between the science curriculum and math curriculum played a major role in my interest to incorporate the NGSS with the math curriculum. Some possible implications for teaching math using the components of the NGSS to students who have been diagnosed with ADHD are that more student driven lessons will lead to better retention, increased communication skills, a stronger focus, the ability to analyze problems to find solutions, the opportunity to work hands on-mathematically, and improved skills in investigating math concepts to explore their importance in the real world setting. Teaching the math curriculum using the NGSS components, teachers may notice more student interest, less disruptions from hyperactivity, improved participation, and possibly increase in student achievement.

This study was conducted across two classrooms in the regular education setting. One class was used as the control group. That class consists of four students with ADHD, using the traditional math curriculum. The other class, also consisting of four students with ADHD, used the components of gathering and reasoning from the NGSS in everyday math lessons.

The independent variable for this study was the two components of the NGSS- gathering and reasoning. The gathering component of NGSS requires to students to obtain/evaluate information, ask questions/define problems, plan and carry out investigations, use models and gather data and information, analyze data and use mathematics/computational thinking (NJACE Science Education Institute, 2015). The reasoning component of the NGSS requires students to evaluate information, analyze and interpret data, use mathematical/computational thinking, construct explanations/solve problems, develop argument from evidence and use models to predict and develop evidence (NJACE Science Education Institute, 2015). Even though each student will have experienced the two components from their current science curriculum, the students will be taught each component as it pertains to the math curriculum. Each requirement for the components may not be necessary for this study. The math concept being taught will determine which requirement will best meet the needs of the students participating in the study. The teacher will develop a phenomenon that is directly related to the math concept being taught that day in the standard math class. The students participating in the study will have access to chrome books to guide research and will also have access to math books to aide in research and evidence. The students will also periodically meet with the classroom teacher who will determine the level of knowledge gained by the study group and the direction they need to keep moving.

The dependent variable in this study was a curriculum-based 21st century math pre-assessment and post-assessment. These assessments were composed of ten mathematical questions, from the current fifth grade curriculum. Each student in the fifth grade is required to take the pre-assessment before the beginning of each chapter. This assessment measures student awareness of the upcoming math concepts and provides the teacher and students with knowledge on the concepts that are weak or lacking.

In conclusion, the components of gathering and reasoning from the next generation science standards were implemented into the standard math curriculum as a strategy to improve the understanding of math concepts with students with ADHD. These components may assist students with ADHD allowing them to be more successful in mathematics.

Chapter 2

Literature Review

Attention deficit hyperactivity disorder (ADHD) is one of the most common *neurodevelopmental* disorders of childhood. According to CHADD (Children and Adults with ADHD), 11% of school-age children are now diagnosed with ADHD (National Resource Center on ADHD, 2016). It is usually first diagnosed in childhood and often lasts into adulthood. Children with ADHD may have trouble paying attention, controlling impulsive behaviors (may act without thinking about what the result will be), or be overly active (Center for Disease Control, 2016). The growing prevalence of the ADHD diagnosis has parents, teacher, and doctors scrambling to find techniques appropriate to aide in the success, socially and academically, for those diagnosed. Children with ADHD might daydream a lot, forget and lose things, squirm or fidget, talk too much, make careless mistakes or take unnecessary risks, have a hard time resisting temptation, have trouble taking turns, and may even have difficulty getting along with others (CDC, 2016). All of these factors may play a role not only in the difficulty of school, but home life, and maintaining friendships.

The management of ADHD is multimodal and may include medication, behavioral and academic interventions. In most cases, ADHD is best treated with a combination of behavior therapy and medication. For preschool-aged children (4-5 years of age) with ADHD, behavior therapy is recommended as the first line of treatment. No single treatment is the answer for every child and good treatment plans will include close monitoring, follow-ups and any changes needed along the way (CDC, 2016). For children 6 years of age and older, the American Academy of Pediatrics (AAP) recommends both behavior therapy and medication as good options, preferably both together. For young children (under 6 years of age) with ADHD, behavior therapy is recommended as the first line of treatment, before medication is tried. Good treatment plans will include close monitoring of whether and how much the treatment helps the child's behavior, and making changes as needed along the way.

Academically, children with ADHD are more likely to have poorer grades, lower scores on standardized tests, greater likelihood of identification for special education, and an increased use of school-based services, compared to peers without the disorder (Loe & Feldman, 2007). There are numerous articles about the different strategies that can be implemented in the classroom to aid in the success for students diagnosed with ADHD. Students with ADHD are also more likely to have a higher absenteeism rate, are three times more likely to be retained during elementary school, are higher risk for dropping out of high school than peers without ADHD (Barberesi, Katusic, Colligan, Weaver, & Jacobsen, 2007). Less research is available concerning methods to remediate academic problems associated with the ADHD, compared to studies regarding ways to treat behavioral and social difficulties associated with the disorder (Jitendra, DuPaul, Someki, & Tresco, 2008). The information mentioned above only supports the need for better resources and interventions that can be used in the school setting. Students with ADHD need to have a chance to be successful, even if the methods and resources are of success are unorthodox. They need a chance, and it needs to be done early in their educational careers.

The most common interventions for students with ADHD include psychotropic medication and behavior strategies implemented in home and school settings (Barkley, 2006). Although stimulant medication frequently is used to reduce ADHD symptoms, pharmacological treatment rarely sufficient in addressing the multiple, chronic difficulties faced by students with ADHD (DuPaul & Stoner, 2003). As a teacher, I have seen medication do wonders for students focus, attention, and hyperactivity. However, the side effects can also have a negative impact on the lives of the students.

Executive Functioning

The link between, ADHD and executive functioning skills has been well documented (Barkley, 2012). One common connection that many scientists, educators, and doctors have linked between ADHD and executive functioning skills is "self-regulation". According to Barkley (2012), since the late 1970s, clinical researchers such as Virginia Douglas who were studying ADHD have asserted that the disorder likely involves a serious deficiency in the capacity for self-regulation. They had begun documenting through various measures that ADHD was associated with deficits in inhibition, managing one's attention, self-directed speech and rule-following, self-motivation, and eventually even self-awareness. If ADHD involves difficulties in these faculties and these are the human mental abilities that are involved in our regulating our own behavior, then logically ADHD ought to be a disorder of self-regulation (Barkley, 2012). Since then, research has continued to affirm the involvement of deficits in these and other mental abilities that are essential for effective self-regulation in people with

ADHD resulting in a tacit acceptance of the idea that ADHD is actually SRDD (self-regulation deficit disorder) (Barkley, 2012).

A commonly used definition in the field of ADHD has been to refer to executive functioning (EF) as “those neuropsychological processes needed to sustain problem-solving toward a goal” (Barkley, 2012). Now we can begin to see a potential relationship between EF and self-regulation, because they share a similar if not identical definition. Both involve goal-directed, future-oriented actions. Both involve sustaining actions over time to achieve one’s goals. And both include problem-solving as part of those goal-directed actions. Moreover, when we look at a list of the mental processes most often listed as being part of the notion of EF, they include: inhibition, resistance to distraction, self-awareness, working memory, emotional self-control, and even self-motivation. These are the very mental abilities that were already identified as being essential to self-regulation. People with ADHD have great difficulties with using their EFs for purposes of self-regulation and attaining their goals (Barkley, 2012).

According to Barkley (2012), executive function is judged by the strength of these seven skills: Self-Awareness: this is self-directed attention, inhibition: also, known as self-restraint, Non-verbal working memory: the ability to hold things in your mind. Essentially, visual imagery — how well you can picture things mentally, Verbal Working Memory: Self-speech, or internal speech. Most people think of this as their “inner monologue”, Emotional Self-Regulation: The ability to take the previous four executive functions and use them to manipulate your own emotional state. This means learning to use words, images, and your own self-awareness to process and alter how we feel about things, self-motivation: How well you can motivate yourself to complete a task when there is no immediate external consequence, Planning and Problem Solving: Experts sometimes like to think of this as “self-play” — how we play with information in our minds to come up with new ways of doing something. By taking things apart and recombining them in different ways, we’re planning solutions to our problems. Anyone who exhibits the classic symptoms of ADHD will have difficulty with all or most of these seven executive functions.

So how does all this affect the academic performance of students diagnosed with ADHD? Twenty to thirty per cent of ADHD children have an associated learning disorder of reading, spelling, writing and arithmetic (Biederman et al, 1991; Pliszka 1998). Children with ADHD are likely to show significant academic underachievement, associated with poor grades, poor reading and mathematics standardized test scores, and an increased likelihood of repeating a school year (Loe and Feldman, 2007). A study was conducted by T.D Barry and colleagues about ADHD and the impact on grades. They examined whether the relationship between ADHD and academic performance could be attributed to problem behaviors associated with the core symptoms of ADHD (i.e. the child does not pay attention in class, does not complete work, etc.) or to the child’s cognitive impairments that could negatively impact on learning. Thirty-three ADHD diagnosed children and 33 controls completed a battery of executive functioning tasks, and were rated for ADHD symptoms severity. Results showed that ADHD behaviors were a stronger predictor of academic performance than executive functioning, and even when controlling for executive functioning, symptom severity significantly predicted academic achievement. However, the ADHD group did not exhibit significant EF deficits, and interaction effects of ADHD and EF were not studied (Daley & Birchwood, 2009).

Barry, Lyman, and Klinger (2002) compared a group of 33 children, who met the *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.; American Psychiatric Association, 1994) criteria for ADHD, with a control group of 33 non-ADHD children. They were looking for academic performance in the areas of reading, writing, and mathematics based on predicted achievement. In this study, the group of children with ADHD performed significantly below prediction in reading, writing, and mathematics skills and demonstrated a greater discrepancy between actual and predicted achievement than did the group of non-ADHD children. The authors stated that children with ADHD experience deficits in some of the abilities constituting the executive functions such as; planning, organizing, maintaining appropriate problem-solving set to achieve a future goal, working memory, cognitive flexibility, and deductions based on limited information (Barry et al., 2002, p. 260). Those executive functions are the cognitive abilities necessary for complex goal-directed behavior and adaptions to a range of environmental changes and demands (Loring, 1999). The attentional processes play a fundamental role in executive functioning, it seems reasonable that that children with ADHD will perform poorly in situations requiring attention and other mental abilities underlying executive functions (Cabrele & Lucangeli, 2006). Barry et al. (2002) found that the ADHD behaviors predicted academic underachievement over and above performance on measures of executive functioning for each of the academic areas (i.e., reading, writing, mathematics). In contrast, performance on the executive function measures predicted academic underachievement in only one academic area-mathematics. These results seem to indicate that disruptive behavior, perhaps more than cognitive deficits, are associated with impairment in academic functioning, including mathematics (Cabrele & Lucangeli, 2006).

Another study conducted by Swanson & Beebe-Frankenberger (2004) found that working memory weaknesses contributed to difficulty in mathematical word problem solving beyond that of phonological processing along. Working memory is an executive function used to help make momentary decisions as well as longer term plans. Working memory is the area in which phonological or visual information is temporarily stored for the purpose of processing and manipulating information (Swanson & Beebe-Frankenberger, 2004, Martinussen & Tannock, 2006). This study provided support for a theory that executive function contributed significantly to solving mathematical word problems. Even when phonological processing, inhibition and math and reading skills were taken out of the statistical equation, a significant relationship still existed between mathematical problem solving and working memory (Swanson & Beebe-Frankenberger, 2004). However working memory is not the only cognitive factor that has been correlated with math disabilities and ADHD. Attention difficulty is highly correlated with ADHD and has also been contributed significantly to math disabilities (Martinussen & Tannock, 2006, Fuchs et al. 2006).

As indicated, mathematical difficulties have been interpreted somewhat differently across studies (Cabrele & Lucangeli, 2006). Most important, specific difficulties in mathematical problem solving skills have not been deeply explored. The main research in problem solving and ADHD has concentrated on general cognitive processes such as text comprehension and mental or graphic representation (Mayer, 1992; Montague, 1992) and the role of working memory or inhibition processes in selecting relevant information (Marzocchi, Cornoldi, Lucangeli, DeMeo, & Fini, 2002; Passolunghi, Cornoldi, & DiLiberto, 1999).

In another study performed by Kaufman and Nuerk (2008) investigated specific aspects of academic difficulties experienced by ADHD individuals by looking at various components of mathematical processing. There were no differences between ADHD-diagnosed and control groups on explicitly trained simple and complex calculation skills, but the ADHD group did perform significantly worse on basic number processing abilities such as comparing the magnitude of single digit numbers.

Students with ADHD and Mathematics

The effect of ADHD on mathematics achievement is a very important concern given the reform movement in mathematics that has been occurring in most western countries in the past 15 years (Cabrele & Lucangeli, 2006). In the United States, for example, graduation requirements in mathematics are becoming more stringent, and performance on high-stake tests often determine whether a student graduates (Cabrele & Lucangeli, 2006). The current diagnostic classification of ADHD (American Psychiatric Association, 1994) is focused on the behavior deficits, such as attention, hyperactivity, and impulsivity, but fails to determine the cognitive and learning deficits that could be associated with ADHD (Barkley, 1997).

Lucangeli and Cabrele (2006) present research findings about the mathematical outcomes of students with ADHD as they relate to mathematical problem solving and calculation. What they found is documented below.

Problem Solving

The main cognitive components involved in problem solving have been studied in typically developing populations and in children with learning disabilities. Most studies have explored the role of text comprehension and the ability to generate appropriate problem representations (Cabrele & Lucangeli, 2006). The semantic comprehension of the textual representation of mathematical problems involves most of the cognitive processes necessary to comprehend other types of text plus knowledge about the meaning of some mathematical terms (e.g. altogether, more than, less than, etc.) (Cabrele & Lucangeli, 2006). According to Mayer (1992) and Montague (1992), the information drawn from the text is connected and integrated in a unified structure where the different variables become related to each other and to unknown data. Furthermore, planning processes are necessary in arithmetic work problem solving (AWPS) to maintain the critical information available and to organize the correct steps to arrive at the solution and to implement the corresponding calculation procedures (Cabrele & Lucangeli, 2006).

In all of these processes, working memory seems to play a crucial role, and this evidence is confirmed by many studies about inhibition processes (Marzocchi et al., 2002; Passolunghi et al., 1999). Passolunghi et al. found that a group of children who had severe difficulties in AWPS (arithmetic work problem solving) also had lower performance in working memory tasks but not in short-term memory tasks. Furthermore, their failure in working memory tasks was associated with a lower recall of target information and higher recall of irrelevant information that had to be inhibited (Cabrele & Lucangeli, 2006). Research seems to indicate that deficits in AWPS may be due mainly to a specific attention deficit and the presence of many off-task behaviors shown by the children during math problem-solving performances (Zentall, 1990; Zentall et al., 1994).

Zentall (1990) tested children with ADHD using four types of problems. The problems had active or comparative verbs, and the same or different math operations. She also recorded off-task behaviors, speed or calculation, IQ, and reading comprehensions skills (Cabrele & Lucangeli, 2006). Her analysis showed that IQ and reading comprehension skills were not predictive of math performance, but that speed of calculation and off-task behaviors were significantly related to performance. In another study, Zentall and her colleagues discovered that problems with questions at the beginning of the text were more difficult to solve because according to the authors, the child had to adapt the text comprehension to the initial questions (Cabrele & Lucangeli, 2006).

Other authors (Lamminmaeki et al., 1995; Marshall et al., 1997; Merrell, 2005; Merrell & Tymms, 2001) studied differences in academic performance in subtypes of children with ADHD with contrasting results. Marshall et al. concluded that children with ADHD without hyperactivity were more impaired in problem solving than those with hyperactivity whereas Lamminmaeki et al. concluded that inattentive children were no more impaired in math than other groups.

Passolunghi et al. (1999) found that poor problem solvers are as good as efficient problem solvers in selecting the most relevant information included in the problems, but they remember a smaller amount of relevant and a greater amount of irrelevant information. This effect could be particularly significant in children with ADHD of the attentional subtype, who have been shown to fail in a variety of cognitive tasks because of their inability to focus on the most relevant information. Another study conducted by Marzocchi et al. (2002) supports Passolunghi et al. study from 1999. Marzocchi et al. (2002) suggests that inattentive children's difficulties in problem solving are partially due to an inability to inhibit irrelevant information, especially when it conveys a rich semantic knowledge.

Inattentive children seem to have a specific source of difficulty in problem solving when irrelevant information overloads the cognitive system. It may be that irrelevant information may crowd the working memory capacity of inattentive children, thus limiting the space for making appropriate decision to solve math problems (Cabrele & Lucangeli, 2006).

Calculations

The research on calculation skills of children with ADHD is even more limited that the research on math problem solving (Cabrele & Lucangeli, 2006). Zentall et al. (1994) were among the first researchers who studied mathematical performance of students with ADHD. One study with 121 nondisabled boys and 107 boys with ADHD in elementary school, they found that the boys with ADHD demonstrated not only significant lower problem-solving ability and conceptual understanding but also slower computation (Cabrele & Lucangeli, 2006). The tasks consisted of addition, subtraction, and multiplication. Zentall et al. recorded two performance measures (accuracy and speed) and three behavioral measures (vocalizations, head movements, and bottom movements). Results indicated that students with ADHD were slower in number recognition and also typing numbers, which may relate to visual-perceptual and visual-motor- deficits that have been associated with ADHD (Stevens, Stover, & Backus, 1970; Zentall & Kruczek, 1988). Therefore the authors suggest that both speed and processing and motor execution time influence calculation performance. In addition, the boys with ADHD were less accurate in calculation than peers (Cabrele & Lucangeli, 2006). Poor performance was attributed to a variety of behaviors that typify ADHD; distractibility (looking away from the task), hyperactivity (overly physically active), and impulsivity (vocalizing during the task) (Cabrele & Lucangeli, 2006).

Studying the arithmetic performance of children with ADHD, Abikoff, Courtney, Szeibel, and Koplewicz (1996) evaluated the impact of extra task stimulation. That is, they compared the arithmetic performance of 20 boys with ADHD and 20 nondisabled boys under three different conditions: high stimulation (music), low stimulation (speech), and no stimulation (silence) (Cabrele & Lucangeli, 2006). The experimental task was 10 computer-generated addition, subtraction, and multiplication problems. Results seemed to confirm that auditory stimulation did not interfere with peer performance of either children with ADHD or their nondisabled peers (Cabrele & Lucangeli, 2006). Nondisabled children, however, performed similarly under the three different conditions, whereas the ADHD children performed better under low stimulation than under the silence conditions (Cabrele & Lucangeli, 2006).

Given the limited research in mathematical calculation and ADHD, we can draw few conclusions. It appears, however, that children with ADHD are slower and less accurate in calculation than nondisabled children (Cabrele & Lucangeli, 2006). There is speculation that this performance deficit is due to overload of working memory caused by the cognitive effort needed in executing calculation. Moreover, the poor performance in calculation may be associated with hyperactivity and distractibility, two major indicators of ADHD (Gagne, 1983; Stoffel, 2004; Zentall, 1990; Zentall et al. 1994). Of interest, there does not seem to be a clear research direction with respect to understanding the impact of ADHD on the development of mathematics-specifically, problem solving and calculation (Cabrele & Lucangeli, 2006). There are, however, interventions that can be implemented to enhance executive functioning and math skills for those children diagnosed with ADHD.

Interventions for Cognitive and Math Performance:

For children to be successful, according to Diamond & Lee (2011), it takes creativity, flexibility, self-control, and discipline. All of those qualities are executive functions, the cognitive control functions needed when you have to concentrate and think, when acting on your initial impulse would be ill-advised (Diamond & Lee, 2011). Studies show that children with ADHD often suffer from deficits in executive functions, such as attentional control, inhibition and working memory (Barkley, 1997; Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005). More complex executive functions include problem-solving, reasoning, and planning. Executive functions are more important for school success than IQ (Diamond & Lee, 2011).

According to Diamond and Lee (2011), there is scientific evidence supporting six approaches for improving executive functioning in the early school year. The six approaches include: computerized training, hybrid of computer and non-computer games, martial arts and mindfulness practices, classroom curricula, Montesssori, and add-ons to classroom curricula.

Swanson and Beebe-Fraser (2004) found that working memory weaknesses contributed to difficulty in mathematical word problem solving beyond phonological processing alone. The most researched approach, and one repeatedly found successful, is "Cogmed" computerized working memory-memory training which use computer games that progressively increase working-memory demands (Holmes et al. Dev. Sci 2011). Children who followed the computer-based working memory program not only showed better performance on related executive function tasks such as logic reasoning and response inhibition and still continued to show effects after three months (Klingberg, Fernell, Olesen, Johnson, Gustafsson, Dahlstrom, Gillberg, Forssberg, & Westerberd, 2005).

Holmes and colleagues examined the effects of this working memory computer-based training on measures of academic ability. Adaptive working memory training proved to be associated with higher achievement on mathematic and working memory tasks immediately and after a period of six months (Holmes, Gathercole, Dunning, 2009). In this study a classroom analogue of a working memory task (e.g. following instructions) was carried out, which showed improvement as well (van der Donk et al., 2013). So far, researched aimed to study the effects of working memory training on academic performance is promising (Holmes et al., 2009 Mezzacappa, Buckner, 2010). Few studies have paid attention to the transfer effects of working memory training on behavior in a classroom setting (van der Donk et al., 2013). Green and Colleagues showed that working memory training in children with ADHD leads to significant reductions of ‘off-task’ behavior during academic task performance. But they also noted that the absence of measurable effects of working memory training on teacher ratings in previous studies is a notable limitation of the training (Green et al., 2012).

Aerobic exercise robustly improves prefrontal cortex function and executive functions (Hillman et al., 2008). Although most studies involved adults and/or examined effects of a single bout of aerobic exercise, which may be transient, the conclusion finds support in three studies of sustained exercise in children (Diamond & Lee, 2011). Davis et al. (2011) randomly assigned sedentary, overweight 7-11 year-olds to no treatment, 20-minutes/day or 40 minutes/day of group aerobic games (running games, jump rope, basketball, and soccer), with an emphasis on enjoyment and intensity, not competition or skill enhancement. Only the high-dose aerobics group improved on executive functions (only the most executive function demanding measure) and math, compared with no-treatment controls. Dose-response benefits of aerobic exercise were found for the most difficult executive function task and math (Diamond & Lee, 2011).

One classroom curricula that has been shown to improve executive functions is Montessori. Even though the curriculum doesn’t mention executive functions, Montessorians mean by “normalization” includes having good executive functions (Lloyd, 2011). Normalization is a shift from disorder, impulsivity, and inattention to self-discipline, independence, orderliness, and peacefulness. Montessori classrooms have only one of any material so children learn to wait until another child is finished. Several Montessori activities are essentially walking meditation (Diamond & Lee, 2011). In Montessori, whole group learning is infrequent, learning is hands-on, often with more than two children working together. Cross-age tutoring occurs in Montessori mixed 3-year age-groups. Such child-to-child teaching has been found repeatedly to produce better outcomes than teacher-led instruction (Mastropieri et al., 2001). At an early age of 5, Montessori children showed better executive functions than peers attending other schools. They performed better in reading and math and showed more concern for fairness and justice (Diamond & Lee, 2011).

One last intervention is the Chicago School Readiness Project (CSRP), which provided teachers with extensive behavior management training and suggestions for reducing their stress. Strategies taught were similar to those in Incredible Years (Webster-Stratton & Reid, 2004) (e.g., implement clearer rules and routines, reward positive behavior, and redirect negative behavior). CSRP intentionally didn’t train teachers in academic instruction, nor provide curricula on academic subjects. It emphasized developing verbally-skilled strategies for emotion regulation (Diamond & Lee, 2011). CSRP teacher provided better-managed and more emotionally-supportive classrooms than control teachers. Executive functions (attention, inhibition, and experimenter-rated impulsivity) or 4-year olds in CSRP classed improved over the year and significantly more so than did executive functions of controls (Diamond & Lee, 2011). CSRP children improved in vocabulary, letter-naming, and math. CSRP's improvement of academic skills was mediated largely via its improvement of executive functions. Executive functions in the spring of preschool predicted achievement 3 years later in math and reading (Li-Grining, Raver, & Pess, 2011).

So, what does this all mean? Executive function training is thus an excellent candidate for leveling the playing field. Executive functions predict later academic performance (Gathercole, Pickering, Knight, & Steggman, 2004). The best approaches to improving executive functions and school outcomes will probably be those that engage students' passionate interests, bringing them joy and pride, address stress in students' lives, attempting to resolve external causes and strengthen calmer, healthier responses, have students vigorously exercise, and give students a sense of belonging and social acceptance (Diamond & Lee, 2011).

The Next Generation Science Standards

In 2010, the National Academy of Sciences, Achieve, the American Association for the Advancement of Science, and the National Science Teachers Association embarked on a two- step process to develop the *Next Generation Science Standards* (NGSS, 2013). The first step of the process was led by The National Academies of Science, a non-governmental organization commissioned in 1863 to advise the nation on scientific and engineering issues (NGSS, 2013). On July 19, 2011, the National Research Council (NRC), the functional staffing arm of the National Academy of Sciences, released the *Framework for K-12 Science Education.* The Framework was a critical step because it is grounded in the most current research on science and scientific learning, and it identifies the science all K-12 students should know (National Academy of Sciences, 2012).

The second step in the process was the development of standards grounded in the NRC Framework. A group of 26 lead states and 40 writers, in a process managed by Achieve, has been working since the release of the *Framework* to develop K-12 Next Generation Science Standards. The standards have undergone numerous state reviews as well as two public comment periods. In April of 2013, the NGSS were released for states to consider adoption (National Academy of Sciences, 2012).

Why Next Generation Science Standards (NGSS)?

The world has changed dramatically in the 15 years since state and science education standards' guiding documents were developed (NGSS, 2013). Since that time, many advances have occurred in the fields of science and science education, as well as in the innovation-driven economy. The U.S. has a leaky K-12 science, technology, engineering and mathematics (STEM) talent pipeline, with too few students entering STEM majors and careers at every level-from those with relevant postsecondary certificates to PhD's (NGSS, 2013).

The current education system can't successfully prepare students for college, careers, and citizenship unless we set the right expectations and goals. While standards alone are no silver bullet, they do provide the necessary foundation for local decisions about curriculum, assessments, and instruction (NGSS, 2013).

Implementing the NGSS will better prepare high school graduates for the rigors of college and careers. In turn, employers will be able to hire workers with strong science-based skills-not only in specific content areas, but also with skills such as critical thinking and inquiry-based problem solving (NGSS, 2013).

The Framework

The Framework outlines three dimensions that are needed to provide students with high quality science education. The integration of these three dimensions provides students with a context for the content of science, how science knowledge is acquired and understood, and how the sciences are connected through concepts that have universal meaning across the disciplines (National Academy of Sciences, 2012).

Dimension 1: Practices. Dimension 1 describes the major practices that scientists employ as they investigate and build models and theories about the world and a key set of engineering practices that engineers use as they design and build systems (NGSS, 2013).

Dimension 2: Crosscutting concepts. The crosscutting concepts have application across all domains of science. As such, they provide one way of linking across the domains in Dimension 3 (NGSS, 2013). They echo many of the unifying concepts and processes in the National Science Education Standards, the common themes in the Benchmarks for Science Literacy, and the unifying concepts in the Science College Board Standards for College Success (NGSS, 2013). The crosscutting concepts include: Patterns, Cause and Effect, Scale and Proportion and Quantity, Systems and System

Models, Energy and Matter in Systems, Structure and Function, and finally Stability and Change of Systems. These are meant to give students an organizational structure to understand the world and help students make sense of and connect Core Ideas (NGSS, 2013).

Dimension 3: Disciplinary core ideas. The continuing knowledge of scientific knowledge makes it impossible to teach all the ideas related to a given discipline in exhaustive detail during the K-12 year. But given the cornucopia of information available today virtually at a touch-people live in an information age-an important role of science education is not to teach "all the facts" but rather prepare students with sufficient core knowledge so that they can later acquire additional information on their own (NGSS, 2013). An education focused on the limited set of ideas and practices in science and engineering should enable students to evaluate a select reliable sources of scientific information, and allow them to continue their development well beyond their K-12 school years as science learners, users of scientific knowledge, and perhaps also as producers of such knowledge (National Academy of Sciences, 2012). The committee developed its small set of core ideas in science and engineering by applying the criteria listed below. Although not every core idea will satisfy every one of the criteria, to be regarded as core, each idea must meet at least two of them (though preferably three or all four) (National Academy of Sciences, 2012).

- Have broad importance across multiple sciences or engineering disciplines or be a key organizing principle of a single discipline (National Academy of Sciences, 2012).

- Provide a key tool for understanding or investigating more complex ideas and solving problems (National Academy of Sciences, 2012).

- Relate to the interests of life experiences of students or be connected to societal or personal concerns that require scientific or technological knowledge (National Academy of Sciences, 2012).

- Be teachable and learnable over multiple grades at increasing levels of depth and sophistication. That is, idea can be made accessible to younger students but is broad enough to sustain continued investigation over years (National Academy of Sciences, 2012).

Performance Expectations

Performance Expectations are the right way to integrate the three dimensions (NGSS, 2013). It provides specificity for educators, but it also sets the tone for how science instruction should look in classrooms. If implemented properly, the NGSS will result in coherent, rigorous instruction that will result in students being able to acquire and apply scientific knowledge to unique situations as well as have the ability to think and reason scientifically (NGSS, 2013).

Due to the nature of some of the Practices, they could not usually be used as a standalone practice (NGSS, 2013). Often, the "Asking Questions" Practice leads to an investigation that produces data that can be used as evidence to develop explanations or arguments. Similarly, mathematics is implicit in all science (NGSS, 2013). There are specific places the standards require mathematics, but the places where mathematics is not explicitly required should not be interpreted as precluding students from using mathematical relationships to support other practices (NGSS, 2013).

There are specific performance sequences that should be incorporated into the science and engineering practices for the NGSS. They are Gathering, Reasoning, and Communicating (Moulding, Bybee, & Paulsen, 2015). Gathering involves the students to obtain and evaluate information, ask questions and define problems, plan and carry out investigations, use models to gather data and information, analyze data, and use mathematics and computational thinking. Reasoning involves students to evaluate information, analyze and interpret data, use mathematics and computational thinking, construct explanations and solve problems, develop arguments from evidence, and use models to predict and develop evidence (Moulding, Bybee, & Paulsen, 2015). Communicating involves communicating information, argue from evidence (written & oral), and use models to communicate.

Since science and mathematics are related, incorporating the Next Generation Science standards into the 5th grade math curriculum to enhance student achievement for students diagnosed with ADHD would appear to be a sound intervention. Since the NGSS is focused on achievement rather than the curriculum, this allows educators, curriculum developers and other education stakeholders the flexibility to determine the best way to help their students meet the standards based on their local needs (NGSS, 2013).

As indicated above, less research is available concerning methods to remediate academic problems associated with ADHD (Jitendra, DuPaul, Someki, & Tresco, 2008).

Studies suggest that executive functioning plays a major role in academic deficits for students diagnosed with ADHD. Executive functions such as; planning, organizing, maintaining appropriate problem-solving set to achieve a future goal, working memory, cognitive flexibility, and deductions based on limited information (Barry et al., 2002, p. 260) are affected by the attentional processes that children with ADHD struggle with. Working memory is an executive function used to help make momentary decisions as well as longer term plans. Working memory is the area in which phonological or visual information is temporarily stored for the purpose of processing and manipulating information (Swanson & Beebe-Frankenberger, 2004). The study concluded that executive function, particularly working memory, contributed to solving mathematical word problems. However, as Martinussen & Tannock, 2006, Fuchs et al. 2006 stated, attention difficulty is highly correlated with ADHD and has also been contributed significantly to math disabilities so therefore working memory and attention difficulty play a role in the mathematical performance of students with ADHD.

According to Diamond and Lee (2011), more complex executive functions include problem-solving, reasoning, and planning. Incorporating the Next Generation Science Standard into the math curriculum, will incorporate the more complex executive functions that are necessary for students to be successful in mathematics. Also, as mentioned above, one intervention that improves executive functions is Montessori. In Montessori, learning is hands-on, often with more than two children working together (Mastropieri et al. 2001). The Next Generations Science Standards was founded based on the hands on approach with peer engagement. Since educators have the flexibility to adapt the standards, many educators use the 5 E’s approach. The 5 E’s include; Engage, Explore, Explain, Elaborate, and Evaluate. In this study, I used the components of Gathering and Reasoning of the NGSS with the support of the 5 E’s approach. This approach may enhance students with ADHD mathematical skills.

Chapter 3

Methodology

Setting and Participants

This study took place in two general education Math classrooms in a 5th grade elementary school in New Jersey. Topics that are covered in the course include rounding: order of operations, writing numerical expressions, problem solving working backwards, patterns, ordered pairs, and graphing patterns.

Eight students participated in this study. All the students had been previously identified as having attention deficit hyperactivity disorder (ADHD). Of the eight students diagnosed, four of them are male and four are female. Two of the males are of Asian descent the remaining three are White. Three female students are White while the third is of Asian descent. The students were randomly assigned to two groups of four students each. One group, the intervention group, was instructed by using the components of Gathering and Reasoning derived from the Next Generation Science Standards (NGSS, 2016). The second group, the control group, received mathematics instruction as usual. Both classes met at the same time each day, from 8:50 a.m. to 9:50 a.m. Students were seated in tables, facing the smart board, but also could move freely around the classroom.

Procedure

Prior to implementation of the intervention each student completed a 21st Century pre-assessment created by the My Math Text book and modified by the instructor. (McGraw Hill, 2011). The pretest contained 10 questions that were a culmination of the concepts that were covered in the upcoming chapter. The pre-assessment had no time limit and all students were instructed that if they reached frustration level to skip the problems and turn in the assessment as is.

The first two problems involved order of operations. Students received one point for question number one if they solved the problem correct and zero points for evaluating the problem incorrectly. The second problem consisting of order of operations was worth two points. If the students gave the correct answer, they earned two points. If the students answered one part of the question correct but not the other part, they earned one point. Zero points were rewarded if both parts of the question were answered incorrectly or not answered at all. The third and fourth problems involved creating and evaluating numerical expressions. If the students wrote the correct expression and solved the expression correctly, they earned two points. If they wrote the incorrect expression and solved the problem wrong, they earned zero points for both parts A and B. For the fourth problem, the students had to create an expression based on given information and then solve it correctly. If students did both the expression and evaluation correct, they earned two points. If they did one correct but the other part incorrect, they only earned one point. If they did both parts incorrect, they earned zero points. Questions number five involved a word problem that involves the strategy of working backwards to solve the problem correctly. If the students solved the problem correctly, they earned one point. If they did not, they earned zero points. Questions number six and seven involved patterns. For number six, the students had to continue a pattern by following the required rule for each pattern. The students also had to identify which pattern would go over sixty first. The students earned two points if they followed the rule of the pattern and identified which pattern would go over sixty first. The students only earned one point if they did either the correct pattern following the rule or just stated the pattern that would exceed sixty first. No points were earned if they did not answer all requirements correctly. Question number seven required the students to identify the pattern that does not belong. The problem had four options and one of the options did not follow the pattern rule the others did. Students earned one point of they identified the correct pattern that did not belong and zero points of they identified the wrong pattern. The last three problems; eight, nine and ten, all involve coordinate planes and ordered pairs. Problem eight consists of two parts, Part A and Part B. Part A has the students describing a path between three towns using the grid lines. For students to earn the one point, they had to write down the correct directions using the grid lines. If students made any errors, they earned zero points. For part B of question 8, students had to determine how many units shorter it would be to move from one town to another without going to the third town. Students earned one point if they identified the correct number of units and zero points of they did not. Question number nine involved the students identifying four points on a coordinate plane by naming the ordered pair. Each point (A, B, C, D) was worth one point. If the students named the correct ordered pair for all four points, they earned a total of four points. If they only named three points correctly, they would only earn three points, and so on. The final question, question ten, also consisted of two parts, A and B. The students were required to find the number of push-ups two people did following a set of rules for each person. For part A, the students had to find the number of push-ups that both people did for the first six days and then graph them as ordered pairs. Students earned two points for each person they graphed correctly, one point if they only graphed on person correctly, and zero points if they did not graph either correctly. For part B, the students had to identify which day the two people would perform the same number of pushups. To earn one point the students had to identify the correct day, they earned zero points of they did not.

During the intervention phase, the intervention group was instructed by using the components of Gathering and Reasoning that were derived from the Next Generation Science Standards. All the concepts that were pre-assessed were included in the study. Each student in the intervention group was given a Microsoft chrome book, a My Math book, and a "phenomenon" worksheet. The "phenomena" worksheet introduced the concept(s) that were taught that day. The students were instructed to read the phenomena and corresponding examples to aide them in creating questions or define the problem. This type of questioning and problem identification represented the Gathering component of the Next Generation Science Standards. From here, the students were asked to hypothesize the strategy or strategies needed to solve the problem. Next, students would use their questions and hypothesis to carry out an investigation using the resources they have (chrome books/My Math books). The students would use research to identify the strategies needed to solve the phenomena. Students would use Google, math websites, and their My Math books to read and analyze information they found to determine if the information was relevant for their success in solving the phenomena. Through their research and analysis, students could evaluate information as it pertains to the concepts, use mathematical and computational thinking, and construct explanations. This process represents the Reasoning component of the Next Generation Science Standards. Lastly, students were evaluated on their findings through multiple problems that covered the concepts.

Normally during the first day of the study, the teacher would model the process of Gathering and Reasoning as it relates to math concepts. However, all students in this study have some background knowledge of the Next Generations Components from their science class. Each concept being covered for this study began with a problem or phenomena. One such phenomenon was: *Phillis was asked to evaluate the following problem by her teacher: 9 -1+ 4 -* 2^2. *Phillis came up with the following answer: 1.*

To begin the process using the components from the Next Generation Science Standards, the students begin with Engage and Explore/Explain, the gathering component of the Next Generation Science Standards.

Engage. *What questions do you have about the problem above? What do you already know about solving the type of problem? Write questions and prior knowledge below*. For the engage section, the students had to create questions that they wanted answered based on the phenomena. They also could write down any information they know about the phenomena. From these questions, the student had a jumping off point as what to research, leading them into the next portion of the gathering component, explore explain.

Explore/Explain. *Determine the process that Phillis used to solve evaluate her problem. Write the steps below. Then, using your chrome books and math books, research to determine the steps necessary to solve order of operations.* For the explore/explain section, the student had to refer to the phenomena and analyze the steps used by Phyllis for how she came to her answer. By documenting her steps, the students then had to research the correct process for solving order of operations. After this portion of research and gathering was complete, the students moved on to the reasoning component of the Next Generations Science Standards and this component involved Elaborating and Evaluation.

Elaborate. Compare your findings to how Phillis solved the problem. Was she correct? Incorrect? Explain. If she was incorrect, solve the problem to find the correct solution. Elaborate involves the student putting together the engage and explore/explain sections together to come to an understanding (reasoning) of the phenomenon. Here the students used their research and compared them to the steps Phillis used to solve the problems in the phenomenon. The students had to explain whether she was correct in solving the problem and had to explain what she did wrong then solve her problem correctly, all based on the research they found while exploring. This lead the students to the last section of the reasoning component, evaluate.

Evaluate. *Solve the following problems by using the strategy you researched.* For the evaluate section, the students were given problems that involved using order of operations. This section is used to check for understanding as to whether the students grasped the concept that was covered. If students successfully grasped the concept, they could move on to the next one. However, if they did not, more gathering had to take place and additional evaluations before they could move on.

After the first day of modeled instruction, students used the components of Gathering and Reasoning for the remainder of the lessons which took 9 days. The teacher checked in from time to time to make sure progress was being made towards the concepts. At the end of each day, the intervention group reported their findings to the teacher. The teacher also evaluated the intervention group to check for understanding and to make sure students grasped the concepts by using the evaluation process as an exit ticket (Figure 1 evaluate) in which both the intervention group and control group completed.

The control group completed class as usual, listening to a lecture, watching modeling, and then working independently all the while sitting in their seats. The teacher began each lesson with a warm up problem, followed by homework review, then on to the lesson. She introduced the lesson using the smartboard and students would listen and sometimes take notes. After modeling of the steps needed to solve the problem, the students were asked to complete problems on their own. The teacher would assist as needed. Toward the end of the period, the class would review their independent work together as a class. From here, they would write down their homework, complete the exit ticket, and leave math for the day.

Variables

The independent variable for this study was a modified version of the Gathering and Reasoning components of the Next Generation Science Standards. Students were given a phenomenon to explain/solve and they could utilize chrome books and/or their

My Math book to explore. The dependent variable in this study was a curriculum-based 21^{st} century math pre-assessment, chapter 7. This assessment was composed of ten mathematical questions, from the current fifth grade curriculum. The students in the study each took the pre-assessment before the chapter began and they also took the pre-assessment at the end of the study that were used to evaluate the results of the study.

Chapter 4

Results

Summary

In this study, the effects of implementing the components of gathering and reasoning from the next generation science standards into the math curriculum for 5th grade students diagnosed with ADHD to increase their math skills were analyzed. Eight students participated in the study, with four students receiving the intervention and four students as the control group, with the teacher conducting the class as usual. The intervention that was implemented was the gathering and reasoning components of the Next Generation Science Standards, each of the components being implemented on the topics being covered on the chapter. The research question to be answered was:

- Can 5th grade students diagnosed with ADHD use the components of Gathering and Reasoning from the Next Generation Science Standards to increase their math skills?

The study began with the students completing a 21st century pre-assessment created by the McGraw Hill publishing company. The pre-assessment contained ten problems that included mathematical concepts such as; order of operations, writing and evaluating numerical expressions, patterns (identifying and continuing), graphing ordered pairs, and graphing ordered pairs as patterns. The pre-assessment did not have a time limit, and all students finished in sufficient time.

Group Baseline Results

Table 1 and 2 show the baseline scores for the control and intervention groups. The intervention and control groups pre-assessments were graded by the researcher.

Table 1

Intervention Group Baseline Assessment Data

Student	Items Correct/Total Items	Percentage
Student 1	8 out of 20	40
Student 2	6 out of 20	30
Student 3	8 out of 20	40
Student 4	6 out of 20	30
Average	**28 out of 80**	**35**

Table 2

Control Group Baseline Data

Student	Items Correct/Total Items	Percentage
Student 1	6 out of 20	30
Student 2	4 out of 20	20
Student 3	9 out of 20	45
Student 4	6 out of 20	30
Average	**25 out of 80**	**31**

Intervention

After the baseline was given, the intervention group was given the components of gathering and reasoning from the Next Generation Science Standards as the main source of math instruction. Students explicitly used this strategy for the nine days of the study. The students worked to explore after a warmup problem and homework review and the evaluate questions served as exit tickets. The control teacher conducted her classroom as she had done in the past utilizing warmups, a homework review, smartboard lessons, modeling, notes, independent work and exit tickets. The control teacher and the intervention instructor also used an on-task analysis to determine the level of engagement for each of the participants. The on-task analysis uses a simple plus/minus code, plus meaning on task and minus meaning off task. The results of this on-task analysis are shown in Table 5 and Table 6. At the end of the nine-day trial, the eight students were given a post-test to see what they have learned or retained. Tables 3 and 4 show the results of the post-test scores for the control and intervention groups.

Table 3

Intervention Group Post Test Assessment Data

Student	**Items Correct/Total Items**	**Percentage**
Student 1	11 out of 20	55
Student 2	15 out of 20	75
Student 3	14 out of 20	60
Student 4	11 out of 20	55
Average	**51 out of 80**	**64**

Table 4

Control Group Post Test Assessment Data

Student	**Items Correct/Total Items**	**Percentage**
Student 1	17 out of 20	85
Student 2	7 out of 20	35
Student 3	14 out of 20	60
Student 4	9 out of 20	45
Average	**47 out of 80**	**59**

Table 5

On Task Analysis: Intervention Group

Student	**Behavior Occurrences**	**Percentage**
Student 1	+ + + + + + - + + On task: 8, off task 1	89
Student 2	+ + + + + + + - + On task 8, off task 1	89
Student 3	+ + + - + + + - + On task 7, off task 2	78
Student 4	+ + + + + + - + + On task 8, off task 1	89
Total	**On task 31, off task 5**	**86**

Table 6

On Task Analysis: Control Group

Student	**Behavior Occurrences**	**Percentage**
Student 1	+ + + + - - - - + On task 5, off task 4	56
Student 2	+ + - - - - - + + On task 4, off task 5	44
Student 3	+ - + - + - + - + On task 5, off task 4	56
Student 4	+ - - - + - - - + On task 3, off task 6	33
Total	On task 17, off task 19	**47**

The difference between the groups' baseline assessments to the post assessment is presented in table 7. The intervention group's percentage went from a 35% to a 64% while the control group's percentage went from a 31% to a 59%. While both groups showed growth, it was the intervention group that showed the most growth even though it was a small margin.

Table 7

Difference Between Pre-and Post-Assessment Scores by Percentages

	Pre-Assessment	**Post-Assessment**	**Difference**
Intervention Group	35	64	+ 29
Control Group	31	59	+ 28

At the end of the study, students from the intervention group were surveyed to determine which procedures they felt worked the best for their math education, the traditional method or the method that used the components of the Next Generation Science standards. All of the students reported that they preferred the use of the Next Generation Science standards method.

Chapter 5

Discussion

This study examined the effects of the components "gathering" and "reasoning" from the Next Generation Science Standards (NGSS Lead States, 2013) to increase math of students diagnosed with ADHD. The participants in this study were students diagnosed with ADHD. Four were assigned as part of the control group and the remaining four were part of the intervention group. A 21st century assessment was used to compare student performance in the control and intervention groups.

The results show that the components of gathering and reasoning from the Next Generation Science Standards had a minimum positive effect on the math skills of the students with ADHD. Both the control group and the intervention groups increased their knowledge of the chapter concepts between the pre-and post-assessments. However, the overall difference for the control group was a 28% increase, comparing the group percentage from 31% to 59%. The students in the intervention group gained 29% from the pre-assessment 35% the post-assessment a 64%. The only 1% of difference between the two groups seems very slight. This may mean that integrating the components of gathering and reasoning into instruction may have limited impact on student performance in learning math.

Research Comparison

According to the Center for Disease Control, (2016), children with ADHD may daydream a lot, forget and lose things, squirm or fidget, talk too much, make careless mistakes or take unnecessary risks, have a hard time resisting temptation, have trouble taking turns, thus have difficulty getting along with others. One study found that poor performance was attributed to a variety of behaviors that typify ADHD including; distractibility (looking away from task), hyperactivity (overly physically active), and impulsivity (vocalizing during the task) (Cabrele & Lucangeli, 2006). Another study found that children with ADHD often suffer from deficits in executive functions, such as attention control, inhibition and working memory (Barkley, 1997, Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005). According to Diamond and Lee (2011), more complex executive functions include problem solving, reasoning, and planning. All of these are areas of weakness for students with ADHD. Regardless, executive functions are more important for school success than IQ (Diamond & Lee, 2011). This study focused on the areas of weakness, such as planning, problem solving, and reasoning.

Previous research has found that a Montessorian curricula has been shown to improve executive functioning skills (Lloyd, 2011). In Montessori, whole group learning is infrequent, learning is hands-on, often with more than two children working together (Mastropieri et al., 2001). Students who were a part of the Montessori classrooms, performed better in reading and mathematics. (Diamond & Lee, 2011). Even though studies have conflicting results that relate ADHD and executive functioning skills, there was enough evidence to suggest that ADHD and executive functioning skills play a role in helping students learn mathematically. Since the Montessorian curricula showed improvement in executive functioning skills and the components of gathering and reasoning from the NGSS are similar in nature, using these components made sense for this study.

Utilizing the past studies found that executive functions such as planning, problem solving and reasoning, are areas of difficulty for students with ADHD, the current study utilized components of the Next Generations Science Standards to enhance executive functioning of students with ADHD. The four students who were a part of the intervention group, did show growth, but it was not significantly more than the students in the control group. Comparing this study to previous research showed similar results. Interventions used with students with ADHD had varying effects on many intended outcomes. According to Cabrele & Lucangelo (2006) there does not seem to be a clear research direction with respect to understanding the impact of ADHD on the development of mathematics, specifically, problem solving and calculation. As with the outcome of this study and Cabrele and Lucangelo's study, these show the need for more research and studies to better grasp the understanding of interventions and their successes and failures for students diagnosed with ADHD.

Limitations

In the current study, it was not determined whether the components of gathering and reasoning from the Next Generation Science Standards improved the understanding of math concepts. These strategies of gathering and reasoning took more time to complete since it was more student driven and research had to be analyzed and concluded relevant to the learning outcome. This time constraint frequently hindered the students of the intervention group from completing enough independent practice to rehearse the strategies needed to master the learning concepts. To determine the effectiveness of the components of gathering and reasoning from the NGSS standards, a longer math period would be required so students in the intervention group could practice the concepts more.

Also in this study, two out of the four students who took part in the control group were also tutored outside of school in the subject areas of mathematics and reading. Their performance increase was higher than all other participants in the study, which suggests that the additional tutoring may have contributed to the improvement of outcomes for these students.

Practical Implications

The participants in the intervention group experienced in learning gathering and reasoning components of the Next Generation Science Standards. The student in this group experienced success with staying focused, finding the math class more enjoyable, and increasing their scores from the pre-to post-assessment. Using a survey, four out of the four students in the intervention group thought that implementing the gathering and reasoning components in the math curriculum made math more enjoyable compared to the traditional method without these components. This increase of enjoyment may have an impact on attendance and skill retention, and possibly leading their success in math achievement. During the study, the control teacher and instructional teacher also recorded their participant engagement using a checklist called On Task Analysis checklist with plus symbols for on-task and minus for off-task behaviors. The participants were observed in each lesson at five minute intervals. When compared to the control group, the students in the intervention group showed more on task behavior than those in the control group. The students in the intervention group showed 86% of on task, compared to 47% of the control with a difference of 39%. The increased-on task behaviors could lead to the likelihood of success in their math achievement.

Future Studies

Future research should examine the effectiveness of the gathering and reasoning components of the Next Generations Science Standards in the math curriculum for a longer period. It could be more accurate if the study lasted longer than one unit, to incorporate covering more chapters to show a positive long term effect on the interventions. Future research should also include a larger sample group with a variety of disabilities. The research design of pre-post control group will be accurately compared if a large group of samples is included to demonstrate valuable outcomes.

Conclusion

This study was seeking an answer to the question: Will the components gathering and reasoning from the Next Generation Science Standards increase math skills for students who are diagnosed with ADHD? The data show that for all four members of the intervention group increased their achievement from the pre-assessment to the post-assessment, however the intervention group not improve significantly more than the control group. It was determined from the intervention students feedback that incorporating the gathering and reasoning components in the math curriculum made math more enjoyable and increased their focus on the learning objectives. Using this intervention proved beneficial for this group of students with ADHD. Even though they did not make more of an impact on their assessment results when compared to the control group, the students began to enjoy math more and increased their focus in class. It would stand to reason that this intervention can be used with not only students diagnosed with ADHD, but possibly with all students who need an extra push in mathematics.

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