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Odyssey Compass Learning Computer-Based Mathematical Intervention for Middle School Students with Autism Spectrum Disorder

by

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Abstract

The purpose of this research thesis is to determine if the computer-aided instructional (CAI) intervention Odyssey Compass Learning would improve math outcomes for nine middle school students with moderate to severe Autism Spectrum Disorder (ASD). Multiple measures were used to evidence students' baseline prior to the intervention. The Odyssey Compass Learning program was then utilized two time per week for 30 minutes for 6 weeks. Post-assessment data was then gathered. The quantitative data revealed that students improved on both assessments after participating in the intervention. Students' scores increased between 2 to 51 points on the Measure of Academic Progress (MAP) Rasch Unit Scale (RIT) score, an assessment from the Northwest Evaluation Association (NWEA). Seven of the nine students showed substantial improvements. In addition, on the Number Sense and Operation Teacher Assessment, students improved in from one to seven mathematical concept areas. The significance of this research is that the intervention is directly linked to standardized assessment data and provides an individualized learning path for each student providing systematic exposure to the CCSS.

Keywords: Autism Spectrum Disorder (ASD), Common Core State Standards CCSS), Computer-Aided Instruction (CAI), Evidence-Based Practice, Measure of Academic Progress), Odyssey Compass Learning, Rasch Unit Scale

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Chapter One: Introduction

Common Core State Standards (CCSS) are a set of high-quality academic standards, in both Mathematics and English Language arts, which provide consistent learning goals and benchmarks across the majority of states. These standards dictate what students should be able to do at the end of each grade level from K-12. Decisions on how to implement the standards are made at the state and local levels. The development of these standards does not include how the standards should be taught. This diversity of options on how to teach the standards leads to different approaches of how to implement them. According to the CCSS, a systematic foundation for acquiring mathematics knowledge begins with whole numbers, addition, subtraction, multiplication, division, fractions and decimals. The middle and high school standards focus on applying mathematical thinking to solve real-world problems. For students with significant cognitive disabilities, while they may not meet grade level standards, need to be making progress toward meeting these goals. Finding effective interventions that are based in the CCSS will help build a body of research for students with ASD. Traditionally, teachers have taught functional math skills such as money and measurement (Browder et al., 2012) while broader access to Common Core State Standards has been limited (Browder et al., 2012). According to the CCSS Initiative, Mathematical Standards, Application to Students with Disabilities (2010),

> Students with disabilities—students eligible under the Individuals with Disabilities Education Act (IDEA) —must be challenged to excel within the general curriculum and be prepared for success in their post-school lives, including college and/or careers. These common standards provide an historic opportunity to improve access to rigorous academic content standards for students with disabilities. The continued development of understanding about research-based instructional practices and a focus on their effective

> implementation will help improve access to mathematics and English language arts (ELA) standards for all students, including those with disabilities (para. 2).

Research is building for effective evidence-based practices for students with ASD. One evidence-based intervention is computer-aided instruction (CAI) and is supported as a best practice for increasing student engagement and learning (Browder et al., 2012). More research in exposing students with moderate to severe ASD to a CAI mathematical intervention will help build this limited area of research and may positively impact future teaching methods and curriculum for students with ASD.

Purpose of the Study

The nature and purpose of this research study is to determine the effects of an assessment-based, individualized computer-aided intervention in the area of number sense mathematics, with a group of nine middle school participants who have moderate to severe ASD. Teachers are expected to expose students to common core curriculum in the area of mathematics per the Individuals with Disabilities Education Act of 1997 and IDEIA 2004 and the reauthorization of the Elementary and Secondary Education Act, also known as No Child Left Behind Act of 2001. The computer-aided mathematical intervention Odyssey Compass Learning program proposed for this research allows students to be engaged at the exact level which matches their strengths to build on areas of their weaknesses within mathematics. Baseline information is obtained from a standardized assessment that links directly to the Odyssey Compass Learning program. Instruction can be done with small groups of students that would require 1:1 instruction without this intervention. The intervention provides teachers with formative, progress monitoring, and summative data to monitor learning. It also provides a systematic, personalized learning path for each student that is engaging. The purpose of this research is to answer the question, does the computer intervention program Odyssey Compass Learning improve math scores for middle school students with ASD?

Preview Literature

A review of the literature helped define ASD and characteristics related to learning. ASD is a pervasive neurological disorder which, while unique to each individual, has common criteria areas that include: deficits in social communication and interaction; restricted, repetitive patterns of behavior interests or activities; must be present in early development and cause clinically significant impairments; all of which may cause challenges to academic progress and impact learning (APA, 2013: CDC, 2014; Charman et al., 2011; Estes et al., 2011; Fleury et al., 2014; Robledo, 2014; Ramdoss et al., 2011). Next the review revealed common core state standard expectations and challenges for this population. According to the Department of Education, whether students with ASD participate in general state assessments or alternate assessments, they must be linked to the common core state standards (Browder et al., 2008; Fleury et al., 2014; U.S. Department of Education, 2003 and 2005). In addition, literature related to teaching mathematics and computer-based interventions uncovered that the area of mathematics for students with ASD is “limited in both quantity and scope” (Browder et al., 2012, p. 27). Finally, the National Professional Development Center on Autism Spectrum Disorders lists computer-aided instruction as one of 27 evidence-based practices as an intervention for students with ASD. Further research in this area will benefit the field and will become increasingly important (Knight, Smith, Spooner, Browder, 2011).

Preview Methodology

This research study will use quantitative research to study the effects of a computer-based mathematical intervention with nine middle school students who have moderate to severe ASD in a severely handicapped, specialized academic instruction, special day class in a public school. Multiple measures will be used to evidence students' baseline prior to the intervention. A Number Sense and Operation Informal Teacher Inventory pre-test assessment will be used with students in a 1:1 setting. The Teacher Inventory Rating scale will assess whether the student has mastered number sense and operation mathematical concepts with answers of "yes," "no," or "unknown." Narrative notes will also be taken and used to assess concept mastery. A standardized Measure of Academic Progress (MAP) assessment provided through Northwest Evaluation Association (NWEA) will also be used to determine baseline, pre-intervention data. Assessment scores are then linked to the Odyssey Compass Learning computer-based intervention where individualized learning paths will be created for each student. The intervention will be utilized for a minimum of 60 minutes per week for 6 weeks. At the conclusion of the intervention, students will again take the NWEA MAP assessment, and scores will be compared to the pre-test for differences. The Number Sense and Operation Teacher Inventory summative assessment will also be given at the conclusion of the intervention period along with narrative notes of student progress. Comparisons will then be made between all pre- and post-test assessments.

Significance of Research

This research is relevant for middle school teachers of students with moderate to severe ASD. It addresses challenges for providing an individualized, assessment based curriculum that meets common core state standards. Research in mathematics for severely cognitively impaired students and students with ASD is limited, with more research related to mathematical functional skills. The significance of this research is that the proposed computer-based intervention is directly linked to standardized assessment data for each student. In addition, research in the area of computer-aided instruction (CAI) interventions for mathematics is also limited (Browder et al., 2008). Results from this math intervention, positive or negative, may influence educators as to whether this is an effective intervention for students who have moderate to severe ASD. If the research results do not show improvements, the research itself may lend information about how to drive future research in this area.

Summary of Chapter

The nature and purpose of this research is to determine the effects of an assessment based, individualized computer intervention in the area of number sense mathematics, with a group of nine middle school participants who have moderate to severe ASD. The review of literature states that computer-based instruction is effective in other academic areas, however, research in the area of mathematics is very limited. In addition, research regarding mathematics focuses mostly on functional math skills and states that further research is needed. Quantitative data will be taken with multiple tools to compare pre-test baselines to post-test scores. Odyssey Compass Learning intervention will be used for six weeks for a minimum of 60 minutes per week. Data will be analyzed to determine if the intervention leads to improved post-test scores.

Definition of Terms

Autism Spectrum Disorder (ASD). According to the Diagnostic and Statistical Manual of Mental Disorders (2013), Autism Spectrum Disorder (ASD) is a neurologic disorder that affects individuals differently but has common criteria areas. The first criteria involves deficits in social communication and social interaction across multiple contexts, which can be manifested by deficits in social-emotional reciprocity, nonverbal communication in social interactions, along with developing, maintaining and understanding relationships. The second criteria definition is restricted, repetitive patterns of behavior, interests, or activities, as manifested by at least two of the following: stereotyped repetitive motor movements or use of objects or speech; insistence on sameness, inflexible adherence to routines or ritualized patterns or verbal/nonverbal behavior; highly restricted, fixated interests that are abnormal in intensity and focus; and hyper- or hypo-reactivity to sensory input or unusual interest in sensory aspects of the environment. Symptoms must be present in early development, cause clinically significant impairment in social, occupational or other areas of current functioning and are not better explained by Intellectual Disability (ID) or Global Developmental Delay. The severity of ASD is defined according to three levels: Level 1 requires support, Level 2 requires substantial support, and Level 3 requires very substantial support.

Common Core State Standards (CCSS). According to the CCSS Initiative, Mathematical Standards, Application to Students with Disabilities (2010), Common Core State Standards (CCSS) are a set of high quality academic expectations in English-Language Arts (ELA) and Mathematics that define the knowledge and skills all students should master by the end of each grade level in order to be on track for success in college and career.

Computer-Aided Instruction (CAI). According to The National Professional Development Center on Autism Spectrum Disorders (2014) through the University of North Carolina, Computer-Aided Instruction (CAI) includes the use of computers to teach academic skills and to promote communication and language development and skills. It includes computer modeling and computer tutors.

Evidence Based Practice (EBP). According to the National Professional Development Center on Autism Spectrum Disorders (2014) through the University of North Carolina, to be considered an evidence-based practice for individuals with Autism Spectrum Disorder (ASD), efficacy must be stablished. This is done through peer-reviewed research in scientific journals using: randomized or quasi-experimental design studies through either two high quality experimental or quasi-experimental group design studies, or a single-subject design study. Three different investigators or research groups must have conducted five high quality single subject design studies, or a combination of evidence. One high quality randomized or quasi-experimental group design study and three high quality single subject design studies conducted by at least three different investigators or research groups (across the group and single subject design studies) will also qualify a practice to be considered an EBP. There are currently 27 identified EBP for individuals with ASD as identified by the National Professional Development Center on Autism Spectrum Disorders (2014) through the University of North Carolina.

Measure of Academic Progress (MAP). A Measure of Academic Progress (MAP) is one of a series of tests developed by Northwest Evaluation Association (NWEA) that measure a student's general knowledge in reading, math, and science and measure growth over time. Scores depend on how many questions are answered correctly and the difficulty of each question. Each Measure of Academic Progress (MAP) is made up of parts, which are called goals. The areas assessed in Mathematics include: Estimation and Computation; Number Sense; Geometry and Spatial Sense; Measurement; Data Analysis, Statistics and Probability; Patterns, Functions, and Algebra; and Problem Solving.

Odyssey Compass Learning. Odyssey Compass Learning is a software package that is for sale to schools and school districts around the country. According to the Odyssey Learning website (2014), it includes lessons and activities that are built upon current and confirmed research. Odyssey is software for elementary and secondary with formative assessments and reporting tools.

Rasch Unit Scale (RIT) Scale. According to the Northwest Evaluation Association (NWEA), the Rasch Unit (RIT) scale is a stable equal-interval vertical scale. Students' academic performance can be compared relative to both the National achievement and growth norms, along with State standards, including the Common Core State Standards (CCSS)**.** The Measure of Academic Performance (MAP) assessments use the RIT scale to create a grade-independent RIT score, which indicates the level of question difficulty a given student is capable of answering correctly about 50% of the time. The RIT scale is a precise measurement of student achievement that is considered valid and reliable. It permits creation of norms based on a nationally representative sample of MAP test scores.

Chapter Two: Literature Review

The nature and purpose of this research study is to determine the effects of an assessment-based, individualized computer intervention in the area of mathematics for middle school participants who have moderate to severe Autism Spectrum Disorder (ASD). Does the computer intervention program Odyssey Compass Learning improve math scores for students with moderate to severe ASD? This chapter presents a review of literature on a computer-aided technological intervention and its impact on academic achievement in the area of mathematics for middle school students with ASD. First, the literature reviews the definition of ASD and the impact of characteristics related to learning. Next the review focuses on assessment and Common Core State Standard (CCSS) expectations and challenges for this population. Finally, literature related to teaching mathematics, best practices and computer-based interventions is reviewed.

Autism and Characteristics Related to Learning

> Autism isn't something a person has, or a "shell" that a person is trapped inside. There's no normal child hidden behind autism. Autism is a way of being. It is pervasive: It colors every experience, every sensation, perception, thought, emotion, and encounter, every aspect of existence. It is not possible to separate the autism from the person-and if it were possible, the person you'd have left would not be the same person you started with (as cited in Robledo, 2014, p. 413).

According to the Center for Disease Control (CDC) and the Autism and Developmental Disabilities Monitoring (ADDM) Network (2010), ASD is a neurologic disorder that affects 1 in 68 children in the United States, is five times more likely to occur in boys than girls, and is present in all ethnic, racial and socioeconomic groups. ASD affects individuals differently, however there are common criteria areas that have been identified by the Diagnostic and Statistical Manual of Mental Disorders (APA, 2013). The first criteria relates to deficits in social communication and social interaction across multiple contexts, which can be manifested by deficits in social-emotional reciprocity, nonverbal communication in social interactions, along with developing, maintaining and understanding relationships (APA, 2013; Charman, Jones, Pickles, Simonoff, Baird & Happé, 2011; Lord, 2010; Fleury, Hedges, Hume, Browder, Thompson, Fallin & Vaughn, 2014; Robledo, 2014). Deficits in communication are often one of the earliest observed symptoms (Ramdoss, Lang, Mulloy, Franco, O'Reilly, Didden, & Lancioni, 2011) and about 33% to 50% of people with ASD do not develop functional speech (Robledo, 2014). When individuals have severe communication impairments, there is an increased risk in developing challenging behaviors which often lead to fewer school opportunities (Ramdoss et al., 2011).

The second DSM-5, 2013 criteria discusses restricted, repetitive patterns of behavior, interests, or activities, as manifested by at least two of the following: stereotyped repetitive motor movements or use of objects or speech; insistence on sameness, inflexible adherence to routines or ritualized patterns or verbal/nonverbal behavior; highly restricted, fixated interests that are abnormal in intensity and focus; and hyper- or hypo-reactivity to sensory input or unusual interest in sensory aspects of the environment (APA, 2013; Charman et al., 2011; Robledo, 2014). Impairments in social communication, and engagement in restrictive, repetitive, and stereotypic behaviors limit a student's ability to learn and present challenges with academic performance (Fleury et al., 2014). The DSM-5 also state that symptoms must be present in early development, cause clinically significant impairment in social, occupational or other areas of current functioning and are not better explained by Intellectual Disability (ID) or Global

Developmental Delay. However, ASD and ID can and do co-occur, along with Attention Deficit Hyperactivity Disorder (APA, 2013). Research also indicates that individuals with ASD may have slower visual and verbal processing rates, especially with simultaneous stimuli, along with slower processing rates of auditory and linguistic information than typical peers (Fleury et al., 2014; Robledo, 2014; Estes, Rivera, Bryan, Cali & Dawson 2011). In addition, impairments in Executive Functioning (EF), which refers to processes that control behavioral regulation and multi-step directions, may also cause potential learning complications and may increase in adolescence (Fleury et al., 2014; Rosenthal et al., 2013). The sensory, motor, communication and behavioral characteristics of students with ASD must be addressed when determining effective interventions (Carter, Trainor, Ye, & Owens, 2009; Charman et al., 2011; Robledo, 2014). According to the National Professional Development Center on Autism Spectrum Disorders (2014) "every identified practice is not necessarily appropriate for every learner. Practices are most effective when carefully matched to a learner's specific needs and characteristics" (What are Evidence-Based Practices, para 1).

For students to be eligible for Special Education, their symptoms must adversely impact educational performance, and there must be a need for special education and related services in order to achieve a free and appropriate education (CDE, 2014; IDEA, 1997; California Department of Education and Individuals with Disabilities Education Act of 1997 and the Reauthorization of the Elementary and Secondary Education Act, 2001). In addition, autism is the fastest growing special education eligibility category not only in California, but nationally according to the California Education Code Section 56846-56847. The DSM-5 defines severity of ASD according to three levels: Level 1 requires support, Level 2 requires substantial support, and Level 3 requires very substantial support. This variability, along with a limited body of research (Xin, Grasso, Dipipi-Hoy, & Jitendra, 2005particularly related to mathematics, makes it extremely difficult to draw general conclusions about academic performance, but it is clear that impairments in communication and repetitive behavior may contribute to challenges in academic performance (Estes et al., 2011; Fleury et al., 2014).

Common Core State Standards (CCSS)

Common Core State Standards (CCSS) in mathematics are a set of high-quality academic standards, which provide consistent learning goals and benchmarks for what students should be able to do at the end of each grade level. Decisions on how to implement the standards are not made at the Federal level, but rather at the state and local levels. No particular curriculum is mandated. This leads to different approaches of how to implement the standards. According to the CCSS Initiative (2014) a systematic foundation for acquiring mathematics knowledge begins with whole numbers, addition, subtraction, multiplication, division, fractions and decimals. The middle and high school standards focus on how to apply mathematical thinking to solve real-world problems. For students with significant cognitive disabilities such as moderate to severe ASD, pupils may not meet grade level standards, but do need to be making progress toward meeting these standards. Finding effective interventions for this population that are aligned with and based from the CCSS will help build a body of research for students with ASD.

Research is building for effective evidence-based practices for students with ASD. One evidence-based intervention is computer-aided instruction (CAI) and is supported as a best practice for increasing student engagement and learning (Browder et al., 2012). More research in exposing students with moderate to severe ASD to a CAI mathematical intervention will help to build this limited area of research and may positively impact future teaching methods and curriculum for students with ASD.

According to the federal policies of No Child Left Behind Act (NCLB) of 2001, mathematical achievement assessment is required for all students (Browder et al., 2008). The National Governors Association Center for Best Practices and the Council of Chief State School Officers released the Common Core State Standards (CCSS) for mathematics in 2012. According to the Common Core State Standards Initiative, 45 states, the Department of Defense Education Activity, Washington D.C., Guam, the Northern Mariana Islands and the U.S. Virgin Islands have adopted the CCSS in ELA/literacy and math. The mathematical standards are a defined set of skills and concepts to be taught across grade levels (CCSS Initiative, 2010). Traditionally students have been assessed on functional skills, such as money, and purchasing skills (Browder et al., 2012). This leaves potential gaps in assessment areas and is a challenge. Whether students with ASD participate in general state assessments or alternate assessments, they must be linked to the state's academic content standards (Browder et al., 2008; Fleury et al., 2014; U.S. Department of Education, 2003 and 2005).

According to Browder et al. (2012) how teachers address state standards for students with moderate to severe developmental disabilities is a relatively new challenge. While Common Core State Standards (CCSS) outline expectations of what should be taught, they do not provide guidance on how skills should be taught (Browder et al., 2012; Fleury et al., 2014). Research supports that students with ASD are able to learn academic content that is aligned with state standards but need appropriate instruction and supports in order to show improved academic performance (CCSS Initiative, 2010; Fleury et al., 2014). The Common Core State Standard Initiative (2010), Application to Students with Disabilities states:

> Some students with the most significant cognitive disabilities will require substantial supports and accommodations to have meaningful access to certain

> standards in both instruction and assessment, based on their communication and academic needs. These supports and accommodations should ensure that students receive access to multiple means of learning and opportunities to demonstrate knowledge, but retain the rigor and high expectations of the Common Core State Standards (para 6).

Research demonstrates that when students are given the proper supports and accommodations, students can access rigorous assessments that are based in the CCSS, holding students to high levels of expectations. The proposed intervention utilizes standardized assessment data based in CCSS of mathematics. It then creates a unique learning path for individual students within the intervention program, linking directly from the assessment, utilizing existing student strengths to teach areas of weakness. This study could add value to this assessment challenge.

Teaching Mathematics, Best Practices and Computer Aided Instruction

The National Council of Teachers of Mathematics (NCTM, 2000) has identified five main components of mathematical instruction including: numbers and operations; measurement; data analysis and probability; geometry; and algebra. According to a NCTM (2000), numbers and operations relates to the ability to understand and represent numbers, relationships among numbers, and number systems and is a “foundational piece from which every other strand feeds” (Browder et al., 2008, p. 407). Research is supported for the need to study effective mathematical interventions, specifically in the area of number-sense and numbers and operations, not only because research is limited, but because it is a foundational area of mathematics. A meta-analysis study by Browder et al. (2008) found that special education teachers were often not aware of the standards and stated lack of materials as an additional reason for not teaching mathematical strands such as algebra, geometry, data analysis and probability to this population. In addition, the meta-analysis showed that “direct instruction was the most effective intervention for increasing basic mathematics skills, whereas self-instruction was more effective in enhancing problem-solving skills” (Browder et al., 2008, p. 408). It also found “strong evidence for using systematic instruction to teach mathematics skills” (Browder, et al., 2008, p. 407) with explicit instruction to learn new academic skills (Fleury et al., 2014). However, it is often challenging to provide the support needed to address each individual student at the exact academic level to offer direct instruction. The intervention proposed utilizes evidence based CAI while teaching mathematics in a systematic manor that is engaging and rigorously designed from the CCSS.

Research with moderate to severe students with ASD related to the content area of mathematics is “limited in both quantity and scope” (Browder et al., 2012, p. 27) and reveals “minimal information on teaching mathematics to students with severe cognitive disabilities, beside health, weather, money, and measurement (Browder, 2008; Cipani & Spooner, 1994; Falvey, 1986; Ryndak & Alper, 2002; Snell & Brown, 2006; Westling & Fox, 2004)” (Browder et al., 2012, p. 26). Research by Fleury et al. (2014) states that more research on academic achievement and instruction for students with ASD is needed, especially in the secondary grades. One research challenge will be to develop strategies that build upon cognitive strengths (i.e., visual processing) while still addressing areas of weaknesses (Fleury et al., 2014). Computer-aided instruction offers a mode of learning that builds on the visual processing strengths of students with autism.

> As the focus on access to the general education curriculum continues for students and teachers of students with ASD and other developmental disabilities, insight in how to discover, refine, and impart evidence-based practices for this population

> will become increasingly important (Knight, Smith, Spooner & Browder 2011, p. 388).

According to the National Professional Development Center on Autism Spectrum Disorders, there are 27 evidence-based practices of intervention for students with autism. Computer-aided instruction (CAI) is one of them. It has been shown to be an effective practice for promoting academic/cognitive and communication skills. Many positive effects of computer assisted instruction have been found according to a study by Traynor (2003) including providing a context for learning that is challenging and stimulates curiosity while decreasing the cognitive load of the learner’s memory allowing other processes to make information relationships. Traynor’s study found that CAI provides animated activities that facilitate engagement and learning becomes highly motivating. Another study found that ASD students had “fewer problem behaviors” (Ramdoss et al., 2011, p. 73) when engaging in CAI. Cardon & Azuma (2012) found that students with ASD showed a visual preference for video presentation with increased attending and “may improve the effectiveness of intervention techniques developed for individuals with ASD” (Cardon & Azuma, 2012, p. 1061). In addition, research found that CAI helps establish “clear routines and expectations, reduce[s] distractions, and provide[s] additional controls for the influence of autism-specific characteristics such as stimulus over selectivity (Moore et al., 2000; Panyan 1984; Silver and Oakes 2001)” (Ramdoss, et al., 2011, p. 56-57). The study by Ramdoss et al., also found the following.

> Software programs may perform many of the tasks often found to be too time-consuming or cumbersome for classrooms with high student-to-teacher ratios, such as providing immediate reinforcement, systematically fading prompts based

upon performance, and collecting data on every response (Higgins and Boone, 1996) (Ramdoss et al., 2011, p. 56-57).

Summary

The purpose of this study is to determine if a CAI intervention will improve student outcomes related to mathematics. Autism characteristics and how they relate to learning were established. Next, research was presented on assessment and Common Core State Standard expectations and challenges. Finally, studies related to mathematics, best practices and computer aided instruction were reviewed. Research is limited in this area and "as the focus on access to the general education curriculum continues for students and teachers of students with ASD and other developmental disabilities, insight in how to discover, refine, and impart evidence-based practices for this population will become increasingly important" (Knight, Smith, Spooner & Browder, 2011, p. 388).

Chapter Three: Methodology

This chapter presents information on the methodology that was used to conduct this research project. The purpose of this study was to determine whether an assessment-based, individualized computer-aided mathematical intervention was effective based on assessment scores. The specific researcher wanted to see if the computer intervention, Odyssey Compass Learning, would improve math scores for middle school students with moderate to severe Autism Spectrum Disorder (ASD). The design of the study was quantitative in nature with pre-assessment scores being compared with post- assessment scores on two assessments. The Northwest Evaluation Association (NWEA) Measure of Academic Progress (MAP) assessment tool will be used along with the Number & Operation K-2 and 3-5 Informal Teacher Assessment and Teacher Rating Scale. This chapter presents information on the design of the study, including detailed information about the participants and setting. The assessment tools will be explained in rich detail. The intervention program, Odyssey Compass Learning, will be described. The procedure that took place during this research study from the pre-test procedures, the intervention and post-test procedures will be reviewed. The chapter will conclude with an analysis of how data was utilized and analyzed.

Design

The design of this research was quantitative. Multiple tools were used to obtain pre- test scores. One tool was a standardized Measure of Academic Progress (MAP) provided through Northwest Evaluation Association (NWEA). The second tool was the Number Sense and Operation Informal Teacher Inventory. Assessment scores from the MAP test were then linked to the Odyssey Compass Learning computer-based intervention, which was utilized as an intervention for six weeks by the participants. At the conclusion of the intervention, summative assessments were taken from both measuring tools, the Northwest Evaluation Association (NWEA) Measure of Academic Progress (MAP) and the Mathematical Number Sense and Operation Rating Scale scores were compared to the pre-test scores, and differences were measured.

Participants

The participants of this research study were nine middle school students from a public school in Southern California. The environment was a special day class requiring specialized academic instruction for students with moderate to severe autism. Participants ranged in age from 11 to 13 years old. Three students were in 6th grade (boys), two students were in 7th grade, (one boy and one girl), and four students were in 8th grade, (two girls and two boys). Participants were selected based on the fact that they were placed into my classroom. Three participants qualified for free and reduced lunch, while five did not. Of the nine research study participants, two had extremely limited verbal communication skills, while seven students were able to communicate verbally. Eight of the students lived within the school district boundaries, while one student was bused in from a neighboring district because an appropriate classroom to meet his needs was not available in his home district. While all students portrayed general characteristics of autism, each student was very unique in how he/she displayed the characteristics of ASD.

What follows is a more detailed description of each of the nine study participants, using fabricated names for their protection. It is important to remember that while each student is unique, these students can be provided with supports and accommodations to access and make progress on academic tasks. I will discuss sensory, motor and behavioral information as well, as these needs must be addressed and met before students can begin to engage with the intervention, and therefor are relevant to this study. Also, a synopsis of each student's academic skill level will be reviewed.

David. The first study participant was David, a 6th grade student with a primary qualifying category of Other Health Impaired (OHI) due to a diagnosis of Tuberous Sclerosis with 30 benign tumors throughout his body. David was also diagnosed with ADHD, Dyslexia and had a history of seizures. However, his secondary qualifying category was Autism (AUT) and was the main factor in placing him within my classroom.

His verbalizations were often garbled, especially if he was talking about an area of interest such as super heroes. However, communication exchanges with direct question and answers were generally reliable and understandable, especially as the year progressed. David lived in a home with both of his parents and two younger siblings and received daily behavior intervention therapy every day after school. David lived in a home with both of his parents and two younger siblings and received daily behavior intervention therapy every day after school.

David recently experienced many major life changes, including a family move, a new school, and an inappropriate placements for the first 30 days into four full inclusion classes. During this transition period, with a full time 1:1 Instructional Aide, David displayed behaviors daily such as hitting, kicking, lying on the ground and thrashing his body, screaming, stomping on other's feet, thrusting sharp objects at staff members, eloping, hiding under desks, and refusing to work. As David fully transitioned into my classroom his behaviors were substantially reduced.

David was at a Pre-K to K level with some splinter skills. Over time, David could read site words up to 2nd grade, but demonstrated basic oral reading and comprehension skills at the kindergarten level. David benefited from picture support and repetition. David had great difficulty with writing and could not write an original sentence. He could verbally dictate an original sentence (with support), from a topic of high interest and then copy the sentence from an immediate model. David could verbally count and write numbers up to 30, but would not write them in order. He would write them floating all over the paper in a random order and very much enjoyed writing numbers on paper (and then coloring that same paper until the paper was full of numbers and colors). David could tell time to the quarter hour. David could add and subtract objects up to ten with manipulatives, a number line with constant verbal prompts to stay focused and to understand what to do next. David could count by 1's, 5's and 10's, but was inconsistent and required re-teaching to regain previously mastered skill. Re-teaching of previously learned skills was on ongoing issue. Parents were continuously working with doctors to monitor his health and see if these regressions related to tumor growth or seizures.

David benefited from our classroom positive reinforcement period by period system, our timers and traffic signal transition signs providing warning and cues for transitions between activities, a highly structured environment, a daily visual schedule, as well as a daily communication log between parents and teacher. David responded to humor, positive attention and benefited from being given choices along with sensory breaks as needed. David responded to working for a preferred activity.

Anna. The second study participant was Anna, an 8th grade student with a primary qualifying category of Autism (AUT) with extremely-limited verbal abilities. Anna was not able to demonstrate the ability to produce independent speech, although she did have limited echolalia, which means she could occasionally repeat back simple phrases immediately after hearing them.

Anna lived at home with her mother, grandmother and her aunt. While Anna was primarily non-verbal, she was also categorized as an English Language Learner. Anna's grandmother, who was her primary care-giver after school, used Spanish as the primary language within the home. However, Anna's mother was fluent in both Spanish and English and communicated with her daughter only in English.

Anna qualified for the free lunch program. Anna was able to follow all classroom routines and structures and was very compliant. Anna required many prompts to stay focused on a task. Anna had trouble with sleep rhythms at night and her mother reported she often only received 4 to 6 hours of sleep. She sometimes had trouble staying awake and benefited from structured sensory input activities prior to an academic tasks and breaks as needed, particularly on days it was reported she received less than 6 hours of sleep, (in which case she was also allowed a nap if needed).

Anna was working at a Pre-K/K reading level, requiring heavy picture support. Anna was very good at copying from a model and had very neat and precise handwriting. Anna could demonstrate counting to 13 reliably, and to 20 with some inaccuracies between the numbers 14-18. Utilizing the Touch Math system, Anna could count by 5's to 25 when touch counting five dots on a quarter, however, she could not demonstrate generalization of this skill. Anna could add with concrete manipulatives or picture support up to five independently, and with prompting to ten. Anna did not display the ability to think of math in the abstract. She required concrete materials in order to demonstrate basic knowledge. Anna could sort domino numbers into matching categories, (matching dot patterns to ten). Anna could not tell which had more or less. If Anna did not understand what was expected of her, she would sit and do nothing and would not indicate she needed help.

Anna benefited from our daily positive reinforcement period by period system, a highly structured visual schedule, transition warnings and cues, being given choices throughout her day, as well as a daily communication log between parent and teacher. She also benefited from structured “brain” exercises and rhythmic movements, especially those crossing the medial position of her body, before beginning an academic task.

Anita. The third study participant was Anita, an 8th grade student with a primary qualifying category of Intellectually Disability (ID) and a secondary qualifying category of Autism (AUT). While Anita’s language ability was simplified in nature, she was definitely able to verbally communicate with others, using very simple sentence structure. She lived at home with her parents and her younger sister. Anita was an English Language Learner, but English was the primary language spoken in the home by all family members.

Anita was reading at a Kindergarten level with heavy picture support. Anita could verbally count to ten and needed some reminders to identify a number presented (would mix up 6, 7, 8 and 9). She had great trouble counting objects and keeping track of the 1:1 relationship between saying the number and touching the object. She could add to five using manipulates and/or picture support, and to ten with more support. Anna could identify time to the hour and half hour.

Anita was very good at following classroom routines and seemed to benefit from shoulder pressure when requested, our daily positive reinforcement period by period system, a highly structured visual schedule, transition warnings and cues, being given choices throughout her day, as well as a daily communication log between parents and teacher. Anita also appeared to greatly benefit from kinesthetic movement activities to complement academic tasks, such as tapping and touching while counting.

Mary. The fourth study participant was Mary, a 7th grade student with a primary qualifying condition of Autism (AUT). She was very verbal, although she sometimes spoke very fast and was hard to understand. Mary benefited from prompts to slow her speech down, but could make her needs, wants and preferences understood. Mary was very interested in having time with neuro-typical students and began to be able to independently go to art class by herself. Mary would seek out relationships during lunch break, however, she sometimes had a hard time comprehending social cues to understand when she was being taken advantage of. Mary lived with her adopted mother, several older adult female siblings and an infant niece. Mary qualified for the free lunch program. Mary was generally very compliant and followed the classroom routines and rules, however, sometimes she became very stubborn, as demonstrated by refusal to do work or a requested task.

Mary could read at a 2nd grade level, and demonstrate comprehension at between 1st and 2nd grade. Mary could tell time to the minute and could count to 100. She could add and subtract to 20 using manipulatives or picture support. She could count by 5’s and 10’s.

Mary benefited from our classroom positive reinforcement period by period system and transition visuals and cues. She was exposed to a highly structured environment, a daily visual schedule, as well as a daily communication log between parent and teacher. She received preferential seating at the front of the class due to a slight vision impairment corrected by wearing glasses.

Thomas. The fifth study participant was Thomas, a 6th grade student with a primary qualifying condition of Autism (AUT). Thomas presented with very limited verbal abilities, and in the beginning of the year, would scream and cry as a form of communication and/or to indicate displeasure. After he became familiar with our classroom, he was able to produce limited independent verbal communications, especially after bouncing on a ball vigorously for 2 to 3 minutes. His screaming and crying subsided substantially as he became more and more comfortable within our room and began to get his sensory and motor needs met. Thomas lived with his mother and father and two siblings.

Thomas also presented with auditory sensitivity and appeared to benefit from wearing head phones when requested, but especially during unexpected loud events, such as a fire drill, during assemblies, or when riding a bus. Thomas also exhibited some anxiety, such as worrying about a fire drill. Thomas positively responded to a very calm, quiet and reassuring voice. In addition, it was determined that Thomas benefited from heavy sensory input and integration as well as proprioceptive activities. He was permitted to use a stationary bike, bounce on a ball, pace, sit on a swivel chair, or play with kinetic sand or lima beans as needed, even during group or independent activities. He benefited from being permitted to hold his sweatshirt hood tightly over his skull, (not fully covering his face) and from receiving squeezes on his head. He became seamless at moving from bouncing on a ball, to sitting in his seat to do work, and returning to a ball as needed.

If Thomas was going to be asked to do an academic task, he greatly benefited from heavy sensory input, such as vigorously bounding on a ball for 2 to 3 minutes, prior to beginning a task. Thomas presented as a Kindergarten level reader requiring heavy picture support, simplified sentences and repetition. Thomas could copy a sentence, but was very literal and would copy exactly as written and how it was written, including where the words were on the paper. If his paper was different than the presented visual model, he did not understand that he had room to finish a sentence on his own paper. Thomas could touch a requested number to ten. He could add and subtract to ten with manipulatives and/or picture support in a 1:1 setting with some prompts. Math was a non-preferred activity.

Thomas benefited from our positive reinforcement period by period classroom system, transition visuals and cues, a highly structured environment, a daily visual schedule, first/then cards, choices, availability to sensory input as needed, and a caring, supportive environment as well as a daily communication log between parents and teacher.

Paul. The sixth study participant was Paul, a 6th grade student with a qualifying condition of Autism (AUT). Paul was very verbal as well as very literal. He was also a very fast, efficient worker who would work for a preferred activity. Paul had strong interests such as animals, drawing, and talking about video movies. He could draw any video tape or DVD cover with the year it was produced and what company produced the film. Paul lived with him mother and father. His grandmother was his primary care-giver after school. Paul also participated in after school activities such as swimming lessons and the after school program 3 days per week.

Paul was a very fast worker and while he did not enjoy working on academic tasks, he was highly motivated to comply with the classroom rules and to work for a preferred reinforcer. Paul was reading at a 2nd to 3rd grade reading level with picture support, and could generally comprehend his reading, sometimes having to go back to the text to find answers when prompted. He could answer who, what, where, and when comprehension questions. He required prompting to understand why something happened, especially if not explicitly stated in the text. Paul could recognize, name and write numbers to at least 100. He could count by 2’s, 5’s, and 10’s. He could tell time very well, and was working on elapsed time math story problems with some prompting. Paul could add and subtract 3 digits numbers without regrouping or carrying. He could add and subtract with regrouping but benefited from a graphic organizer to prompt him borrow. He could multiply numbers to 10. He could complete 2 and 3 digit multiplication problems with a graphic organizer and steps to remember the process. He could do 2 digit division problems without a remainder. Paul displayed the ability to think about numbers in an abstract manner and could answer simple story problems, with some prompting.

Paul benefited from the classroom positive reinforcement period by period system, transition visuals and cues, an individualized reinforcement card to earn a preferred activity, a first/then card, a highly structured environment with a visual schedule, and the ability to work for a preferred choice activity. He also benefited from a daily communication log between parents/grandmother and teacher.

Robert. The seventh study participant was Robert, an 8th grade student with a qualifying condition of Autism (AUT). Robert was very verbal, and had a marvelous sense of humor. He would enjoy telling jokes and responded to a sense of humor in others. Robert had an oral fixation, and would chew on pencil erasers, paper, small straws, or objects he would find on the ground. Robert lived with his mother and father and two younger siblings. Robert was very sensitive to other people crying and would be prompted to leave the room if this happened, which helped him stay in control of his behaviors. Robert had strong fascinations with cars and loved to draw designs.

Robert also had some impulse control issues and would sometimes touch other people's stomach or body. Robert had a difficult time with transitions and benefited from being able to have more time for transitions, along with lining up last, utilizing a transition chair with a visual cue, and reading a social narrative. In addition, Robert benefited from, and was allowed to, receive a break if he verbally requested one or one was suggested to him. Robert required encouragement to work in any area that was non-preferred, but would engage for a highly preferred reinforcer, and when allowed to take breaks. He would return to work when his break was over.

Robert was a 3rd to 4th grade reader (or higher), but hated reading. He would not engage if there were too many words on a paper and benefited from picture support and heavy positive reinforcement. He could read individual words to 7th grade. He very much enjoyed listening to stories, especially picture books, read to him. Robert could answer comprehension questions. Robert could count to at least 100, and could add and subtract. Robert would sometimes fixate on certain numbers (13 and 17) and colors. In addition, Robert would remember people's birthdays and would be able to state the day a person was born. He displayed the ability to think about math in the abstract but generally math was a non-preferred activity. Robert could tell time, and had great difficulty understanding money concepts such as how much money to present when paying for an item. He had trouble generalizing learned skills to life skills, unless it was highly preferred.

Robert benefited from our classroom positive reinforcement period by period system, transition visuals and cues, timers, more time for transitions and a highly structured environment. In addition, Robert benefited from an individual reinforcement star chart to earn a preferred activity of his choice at least two times daily, as well as a daily communication log between parents and teacher.

Joseph. The eighth study participant was Joseph, an 8th grade student with the qualifying condition of Autism (AUT). Joseph lived with his mother and father. He was a verbal student who required unexpected movement breaks, such as being allowed to suddenly jump up out of his seat to pace for about 30 seconds to a minute. He would return to his seat when requested or on his own. Joseph had obsessive and compulsive tendencies along with exacting routines.

Joseph would always wear a special brand of ear buds to help reduce sound and/or just because he liked the way they felt on his ears. He had to have a water spray bottle to cool his body as needed, and sunglasses for outside. If something happened to his preferred objects or if he was asked to do a highly non-preferred activity, Joseph might display behaviors such as violently throwing his body against a wall, hitting, kicking, screaming, disrobing, running, laying on the ground while thrashing, or eloping.

Sometimes if Joseph was hot, or when experiencing a state of high emotion (positive or negative) he would present with an itchy, prickly rash all over his body. Joseph was able to sit in front of a fan and let his body relax. Joseph required more physical space around his body and didn’t like when people or their objects entered into his area. When sitting at the bank of computers in our classroom, he needed to be placed on the end, so that no one was seated next to him. Joseph benefited from a privacy board between himself and student adjacent. In addition, he was incapable of listening to the computer with the computer headphones, since he preferred not to remove his ear buds, so he listened to the computer over the speakers.

When printing, Joseph needed to have a very sharp pencil and each and every line needed to be absolutely correct. Joseph would erase and rewrite until he was satisfied. In addition, he would use excessive force to continue to trace over and over each letter, causing finger fatigue. If his pencil broke, and he was allowed to sharpen his pencil, he would sharpen it down to the stub in an attempt to get it sharpened perfectly. Joseph did not respond well when requested to stop working on a task before he was finished. Joseph was very capable of creating a very detailed sentence, when presented with a picture and word bank. However, writing or typing the sentence was a very lengthy process including time to decide what to include in the sentence and the physical time to write and/or type it.

Joseph benefited from holding a fidget, and preferred to use his finger nail to scrap the paint of off pencils, or scrap layers off of a large pink eraser. He would also pick up small objects, such as pieces of dirt or paint outside and put them in his mouth. Joseph had difficulty with executive functioning, such as making a decision and benefited from being given a choice of two, and even that was sometimes difficult.

Joseph often required from 5 to 30 prompts to complete a non-preferred task. Joseph preferred using the computer, however, if something happened and he made a typing mistake, lost information, or something happened to his web history, he was capable of suddenly punching a computer, as well as the other behaviors stated previously. When reading, he was not able to turn a page, unless it was perfectly folded. Joseph required space around his body.

Joseph was able to read at between a 3^{rd} to 5^{th} grade level or higher, but reading was a very non-preferred task. He benefited from less on a page and picture support. He also received heavy positive reinforcement and was motivated to work for a highly preferred reinforcer, such as computer time. Joseph could answer comprehension questions with prompts to keep going and to stay focused. Joseph could count, recognize and write numbers to at least to 100. He could add and subtract 3 digit numbers with carrying and regrouping, sometimes needing a graphic organizer to remind him to borrow. He could demonstrate 3 digit multiplication problems. He could divide 2 digit numbers without a remained.

Joseph utilized an individual reinforcement system, earning icons to work for a preferred activity or object. He benefited from our daily positive classroom reinforcement period by period system along with transition visuals and cues. He also benefited from a highly structured environment, a daily visual scheduled, and utilized a daily communication log between parents and teacher.

Mark. The ninth study participant was Mark, a 7th grade student with a qualifying condition of Autism (AUT). Mark was the age of an 8th grader because he repeated 1st grade. Mark was also diagnosed with ADHD and displayed impulse control and anger issues. Mark very much enjoyed being able to use the computer. Mark lived with his mother.

Mark required lots of positive reinforcement, redirection and intervention to keep his behaviors under control. At times, Mark would tease, laugh under his breath, draw inappropriate cartoons, and impulsively touch females. Mark sometimes became very upset. He would rip paper, hit, kick, scream, throw objects, swear and/or threaten. He was able to utilize a self-calming chart/system when prompted and benefited from walking to calm his body. He utilized a personalized behavior intervention system to self-evaluate his behavior, along with an individualized slam dunk basketball reinforcement system to earn a choice activity. Besides walking and running, Mark also benefited from sensory input such as shoulder pressure.

Mark tested for reading much lower than he was sometimes able to demonstrate at 2nd grade. Mark was in an inclusive Language Arts class, with modifications and accommodations. Mark could read easier novels (3rd to 6th grade level) with support and assistance if they were of high interest. Mark also benefited from a study skills class, where he engaged in 2nd grade reading fluency material. Mark was in a science class, with modifications and adaptations. Mark had a very good ability to listen, but had trouble completing more than one processing skill at a time. For example, he could not listen to a lecture and take notes about the lecture at the same time. The physical act of writing was a weakness, but his verbal ability to speak in more complex sentences and dictate was a strength. He benefited from good receptive listening skills. Mark also attended an inclusive math class. Mark could complete simple math operations in head and had a great ability to think of math in the abstract. He could add, subtract, and complete one digit multiplication and division problems. Mark could answer elapsed time questions. Mark had some trouble with the processes of multiplication and division with multiple numbers, and benefited from graphic organizers. Mark sometimes had trouble generalizing his math ability. He also benefited from help to identify the process of obtaining answers. Mark has lots of skills and lots of holes in his skill level as well.

Mark benefited from heavy positive reinforcement for doing appropriate behaviors and would build on that positive momentum. He utilized a special period by period reinforcement system for behavior, as well as the standard classroom positive reinforcement system. He utilized transition visuals and cues, especially for transitioning between highly preferred and non-preferred activities. A daily communication log between parent and teacher as also utilized.

Setting

The setting for this research study was in a city of about 143,000 people located in Southern California. While all income levels were represented within the city, the middle school was considered a high-poverty school with a population of 59.1 percent of students deemed socioeconomically disadvantaged. High-poverty schools were defined as those schools with student eligibility of approximately 40 percent or more in the free and reduced price meals program. Total student enrollment at the middle school was approximately 1250 students and serviced students in 6^{th}, 7^{th} and 8^{th} grades. School demographics were as follows: Black or African-American 3.1%; American Indian or Alaska Native 0.7%; Asian 3.2%; Filipino 2.7%; Hispanic or Latino 55.4%; Native Hawaiian or Pacific Islander 0.2%; White 27.1%; Two or More Races 1.1%; Socioeconomically Disadvantaged 59.1%; English learners 41.2%; students with disabilities 10.9%.

The last reported school API was 784. While the middle school from the research study was not in Program Improvement, 36 percent of schools within the district were in Program Improvement. The middle school listed 100% of teacher as highly qualified with full credentials within their subject area of competence. The classroom teacher, this researcher, held three highly qualifying credentials in Multiple Subjects K-8, Education Specialist-Mild/Moderate, and Education Specialist- Moderate/Severe. Within the classroom setting, there were nine students, one fully credentialed teacher, two six hour instructional aides and one 3.45 hour instructional assistant. The classroom had a bank of five computers available to students. Also adjacent to the classroom was an interior pod (small classroom) with a round table and chairs.

Instruments and Procedures

Pre-Assessment: Measure of Academic Progress (MAP). The first procedure of this research study was to administer the school district prescribed standardized Measure of Academic Progress (MAP) assessment provided through Northwest Evaluation Association (NWEA) to the research participants. Typical students have been assessed using this tool 3 times per year within the school district where this research took place, however, students with moderate to severe autism have not been expected to engage with this assessment tool up to the point of this research study. The middle school students in this research study had not attempted this assessment previous to this study.

This paragraph will describe rich information about the Northwest Evaluation Association (NWEA) Measure of Academic Progress (MAP) assessment tool. According to the website www.NWEA.org. (2014) the NWEA is a global not-for-profit educational service that provides the MAP assessment and is the evaluation partner to the Odyssey Compass Learning intervention. This assessment was provided through the school district where this research took place. The NWEA offers assessments that accurately measure student growth, learning needs and provides research that supports assessment validity. The MAP assessment measures students' growth using an empirically-derived scale based on Danish mathematician Georg Rasch's Item Response Theory model. Rasch is best known for his contributions to psychometrics, and his model is used extensively in assessment in education, particularly of skill attainment and cognitive assessments. The NWEA RIT (Rasch Unit) scale accurately measures student growth over time. The RIT scale is a curriculum scale that uses individual item difficulty values to estimate student achievement. RIT scores help educators understand student's current achievement level based on their zone of proximal development (ZPD). The ZPD is the difference between what a learner can do without help and what he or she can do with help. An advantage of the RIT scale is that it can relate the numbers on the scale directly to the difficulty of items on the tests. In addition, the RIT scale is an equal interval scale. Equal interval means that the difference between scores is the same regardless of whether a student is at the top, bottom, or middle of the RIT scale, and it has the same meaning regardless of grade level. RIT scales are built from data about the performance of individual examinees on individual items. Teachers can compare students' academic performance relative to: National achievement and growth norms State standards, including the Common Core State Standards (CCSS). Characteristics of the RIT Scale include: it is an achievement scale; an accurate scale; an equal interval scale; it helps to measure growth over time; and has the same meaning regardless of grade or age of the student. The RIT scale is a mature, stable scale which supports the strength of the MAP assessments by supplying valid, reliable, and predictive data. In addition, NWEA MAP assessment data links directly with the intervention instrument for this research. The following is a MAP description from the Compass Learning Solutions Catalog 2014-2015 at www.compasslearning.com.

> Northwest Evaluation Association™ (NWEA™) provides a computer-adaptive assessment suite that quickly pinpoints student proficiency and identifies appropriate learning goals. Together, Compass Learning and NWEA maintain a deep alignment between the NWEA MAP® (Measures of Academic Progress) assessment and the Compass Learning digital learning progressions to automatically provide each student with a personalized learning path based on his or her RIT range at the sub-strand level (p. 20).

The formative MAP assessment was the first assessment tool used in this research study. The assessment took place first thing in the morning, immediately after announcements and attendance, which is the most beneficial time for these research participants to engage in an academic task. The location of the test was in the school computer lab, located on the opposite side of campus from the classroom. One student, Thomas, was allowed to bring a large exercise ball to sit on while taking the test. Another student, Joseph sat on a computer away from other students and was given stars for completing tasks (such as walking to the computer lab). Mary wore glasses and Robert was allowed to re-number his computer using a sticky note and a magic marker (to # 17). The teacher was present during the MAP assessment, along with the school testing coordinator/reading specialist and 3 instructional assistants. Students were provided with support to stay on task. Students completed the assessment at various times. There was no time limit for this assessment. MAP RIT scores were available within one day.

Pre-Assessment: Number & Operation Assessment. The second assessment was conducted in a private room directly adjacent to the classroom, in a 1:1 setting. The Number &

Operation K-2 and 3-5 Assessment was utilized along with the Teacher Inventory Guide to indicate whether number sense and operations mathematical concepts were mastered or not. Anecdotal notes were also captured. If the student appeared to master concepts and was not at a frustration level, the 3-5 grade assessment was continued until frustration level was achieved. Questions were designed to help assess student's current needs and allow for student and teacher to spend time working through the questions. After each question, the teacher determined whether the student seemed to have a good understanding of the concept or whether he or she would benefit from additional help. It was also understood that the student may be able to complete some of the questions on the Assessment, but may still need work in the area, and indicators such as how long it took for the student to do a task or whether he or she did the task with ease were considered. Concept mastery of Numbers/Patters included: Concrete Representation of Numbers; Number Patterns; Factors and Multiples; Prime and Composite numbers; Number Relationships; Names of Numbers up to 1,000,000; and Place Value. The concepts for Computation and Arithmetic included: Addition/Subtraction: 2 digits, no regrouping; Addition/Subtraction: 2 digits, regrouping; Multiplication/Division; Arithmetic Fact Practice; Relationships between Operations; Order of Operations; and Properties of Operations – Arithmetic. Concept mastery of Fractions included: Representing Fractions; Identifying Fractions; Comparing Fraction Sizes; Equivalent Fractions; and Fraction Addition and Subtraction. Strategies assessed include both Estimation and Counting Strategies. This assessment took 2 weeks to compete, as each student was assessed individually and took between 2 to 6 hours for each student, depending on the number of breaks each student required, the extent of student knowledge, and how far they each progressed through the assessment before frustration level was achieved, at which point, the assessment was discontinued. However, all students were assessed on all of the K-2 (ten) assessment prompts.

Intervention: Odyssey Compass Learning

Compass Learning Odyssey was an online program/website that provided scientifically based curriculum that incorporated the latest research in effective pedagogy. Compass Learning imported test data for each research participant from their MAP assessment, and automatically generated a personalized learning path based on students' scaled scores using strengths to address challenges. The program included highly engaging video, animation, audio, graphics and tools, and provided non-repetitive re-teaching. In addition, the computer-aided intervention (CAI) provided for students to have reduced cognitive load, by providing graphic organizers and concept maps that provided scaffolds with learning sequenced from simple to complex. A gradual release of responsibility to the student through observing models, multiple scaffolds, fading of scaffolds, and from learning from their own mistakes and successes, provided instructional support, but was also a source of motivation for the learner. In addition, the student-friendly learning environment increase the efficacy of the learning experience as students were active participants, rather than passive receivers of information.

The next step was introducing the students to the intervention, Odyssey Compass Learning. All students previously knew how to log onto the computer and had experience going to instructional websites. Some students' required assistance to enter their computer log-in and password. Simple web-hunts with explicit picture supported directions were already a part of the classroom curriculum, as well as visiting and engaging in other educational websites. Students were educated about how to log onto the specific Odyssey Compass program and explicit directions were discussed and modeled with each individual student. Once in the Odyssey

Compass Learning program, students had a “back-pack” they clicked. Within their back-pack were folders of work assignments. Assignments were completed in a linear fashion, so that students could not proceed to the next assignment until the first one was completed with mastery of at least 70% achieved. Students were allowed to repeat lessons as needed to achieve the minimum required mastery as demonstrated on assignments, quizzes and tests. Students engaged with the intervention a minimum of 2 times per week for a minimum of 30 minutes per session.

Students completed research-based instructional activities that were targeted to identified learning needs. Every time a student completed a lesson, it was counted toward their individual progress. Student progress showed what lessons and quizzes had been completed. When each stage was completed, the student saw a check symbol indicating the activity was completed. The program offered the following: ongoing effective feedback; explicit instruction and the gradual release of responsibility; a student-centered learning environment; reduced cognitive load; with a diagnostic-prescriptive model.

The teacher and instructional aides monitored student activity to ensure appropriate progress was being made, but the students assumed the most active role in the process. An instructional aide was always within 3 feet of each student working on the program, ready to provide sensory, motor, behavioral or additional support as needed to each research participant. Effective feedback was also provided to students as Compass Learning provided multiple activities and assessments that students completed each week as part of their customized learning path. Feedback came to students in the form of both scored and unscored activities. Students complete 4 to 6 activities per week. Data was generated by students in the system and includes assessment scores, time-on-task, number of tasks completed, and percent of learning paths obtained. A comprehensive progress-monitoring report was generated weekly and sent to the researcher’s email. If a student did not make expected progress after being allowed to repeat an activity 3 times, the assignment folders were re-assigned and more support was provided to the student.

Accommodation of the Intervention by Student

Accommodations were provided to all students to ensure successful engagement for both assessments, as well as for the intervention itself. It should be noted that none of the students involved in this study found the intervention to be non-preferred, therefore transition issues onto the intervention were minimal, although transition visuals and cues were still utilized. Students with autism benefit when their sensory and motor needs are met. This helps them be more in control of their behaviors, which in turn sets them up to access the learning objectives. A review of each student’s accommodations will now be provided.

David. David, a 6th grade students, was provided positive reinforcement for engaging in the intervention program and utilized transition visuals and cues to both begin and finish computer time. He was also offered verbal prompts for focus if needed. On days that behavior issues surfaced, David was allowed to work for a colored picture of a Marvel Character of his choice.

Anna. Anna, an 8th grade student, utilized transition visuals and cues to get on and off the computer. She also benefited from structured sensory input activities immediately prior to engaging with the intervention. These included “brain” activities and rhythmic movements, especially those crossing the medial position of her body. In addition, if Anna came to school with less than 6 hours of sleep, she was offered a nap prior to being asked to engage in the intervention.

Anita. Anita, an 8th grade student required verbal and/or gestural prompts for focus, especially if there were any classroom interruptions or disruptions. She utilized transition visuals and cues, shoulder pressure, and kinesthetic movement activities to complement academic tasks, such as tapping and touching while counting. While Anita was engaging in the program and witnessed to be losing focus while completing a counting activity, she would be asked to step away from the computer and engage verbally and kinesthetically in a counting and kinesthetic movement activity, (e.g., verbally counting while toughing elbows to opposite knees as she marched in place). She would then resume time on the computer intervention.

Mary. Mary, a 7th grade student, utilized transition visuals and cues, and wore glasses for corrected vision.

Thomas. Thomas, a 6th grade student, required transition visuals and cues as well as engaging in a vigorous physical activity prior to engaging with the intervention, such as intense bouncing on a seated exercise ball for 2 to 3 minutes. In addition, he would sit on the ball and bounce as needed throughout the entire time he was engaging with the intervention. He was also offered shoulder pressure, a weighted vest and brain squeezes as needed.

Paul. Paul, a 6th grade student, was provided with transition visuals and cues and also a timer so he would know exactly how much time until he was finished. When he was finished with the intervention, he was allowed to engage in a reinforcing choice activity.

Robert. Robert, an 8th grade student, benefited from extra time to transition onto the computer. He utilized transition visuals and cues and a timer to indicate when he was done. He was allowed to use a sticky note and marker to number his computer what-ever number he needed it to be, (usually 13 or 17). He was allowed a choice activity when he had completed the required time on the intervention program, but once he was engaged with the program, he often would keep going until prompted to stop.

Joseph. Joseph, an 8th grade student, required an assigned computer while engaging with the intervention. Joseph required lots of space around his body, and sat on the end, so that no one was seated to his left. He also required a privacy board to be located between himself and the student to his right. In addition, he needed to listen to the computer program over the speakers, because he would not discontinue wearing his preferred ear buds. He required movement breaks as needed. He also required close monitoring. If it was suspected Joseph was getting frustrated, staff would either ask him to take a break, or give him more assistance to prevent a negative behavior like suddenly punching the computer, screaming and running around.

Mark. Mark, a 7th grade student, required constant positive reinforcement for correctly completing any step, such as calmly walking to the computer, turning on the computer, logging in, going to the correct program, etc. He utilized a personalized positive reinforcement basketball "slam dunk" system to earn a preferred activity. Mark was offered shoulder and head pressure. He was asked to pause the program if he needed to calm his body by walking. In addition, Mark was closely monitored due to his impulsivity. Mark would sometimes press the computer mouse impulsively and then get frustrated if he made a mistake. He benefited from an instructor talking him through the math problem and from someone reading the problems to him, even though he could listen through the ear phones. This helped lower his frustration level and build on positive momentum and prevented impulsive mouse clicking.

Post-Assessment on Measure of Academic Progress (MAP)

At the conclusion of the intervention, students were given a post-test Measure of Academic Progress (MAP) assessment provided through the Northwest Evaluation Association (NWEA).

Students were assessed first thing in the morning, the most beneficial time for the research participants to take an academic assessment. Students were assessed in the computer lab on the other side of the campus and benefited from walking to the computer lab to prepare for the assessment. Thomas was allowed to bring a large exercise ball to sit on while taking the test. Joseph sat on a computer away from other students and was given icons for completing tasks (such as walking to the computer lab). Mary wore glasses and Robert was allowed to re-number his computer using a sticky note and a magic marker (to # 17). The teacher was present during the MAP assessment, along with the school testing coordinator/reading specialist and 3 instructional assistants. Students completed the assessment at various times. There was no time limit for this assessment. MAP RIT post-test scores were available immediately and ready for comparison again pre-test scores.

Post Assessment on Number & Operation Assessment

In addition, a post-test Number & Operation K-2 and 3-5 Assessment was conducted with the Teacher Inventory Guide. Anecdotal notes were also captured. If the student appeared to master concepts and was not at a frustration level, the 3-5 grade assessment was continued until frustration level was achieved. All students were assessed on the K-2 assessment. This assessment was conducted in a 1:1 setting in a private adjacent room with the teacher. Anecdotal notes were obtained. Questions were designed to help assess student's current needs and allow for student and teacher to spend time working through the questions. After each question, the teacher determined whether the student seemed to have a good understanding of the concept or whether he or she would benefit from additional help. It was also understood that the student may be able to complete some of the questions on the Assessment, but may still need work in the area, and indicators such as how long it took for the student to do a task or whether he or she did the task with ease were considered. Concept mastery was then determined and ready for comparisons to be made to pre-test assessments.

Analysis of Results

This research study was quantitative in nature. Numerical scores from the standardized Measure of Academic Progress (MAP) RIT scale pre-test scores were mathematically compared with post-test scores and differences were measured. The Number Sense and Operation Informal Teacher Inventory pre-test assessment with Teacher Inventory Rating scale was used to identify concepts mastered by each student. Post-test concepts mastered were then compared with pre-test concepts mastered and differences were noted. In addition, the researcher personally reflected on each of the nine participants experience with the intervention to see if other variables may have impacted student scores.

Summary

This chapter reviewed the methodology used in this research study. The purpose of the research was to determine if a mathematical computer-aided intervention was effective for middle school students with moderate to severe ASD. The design of the study was quantitative. The participants and setting were discussed in rich detail. The research instruments were described along with the procedures utilized for the research. Pre-test scores were obtained and compared to post-test scores utilizing two assessment tools and differences were measured. Finally, analysis of how the research will be analyzed was reviewed. The next chapter will present the data findings as well as an analysis and interpretation of the data.

Chapter Four: Results

This chapter presents results of this research study, including data analysis and interpretation of the results. Common Core State Standards (CCSS) provide consistent learning goals and benchmarks that dictate what students should be able to do at the end of each grade level but decisions on how to implement the standards are made at the state and local levels. According to the CCSS Initiative, Mathematical Standards, Application to Students with Disabilities (2010), students with significant cognitive disabilities may not meet grade level standards, but do need to be making progress toward meeting these benchmarks and standards. The CCSS provide an opportunity to improve access to rigorous academic content standards for students with severe cognitive impairments and students with Autism Spectrum Disorder (ASD). Research on effective mathematical interventions specifically targeted for this population is very limited (Browder et al., 2012). Finding effective interventions that are based in the CCSS will help build a body of research for students with ASD. The purpose of this research study was to determine the effects of an assessment-based, individualized computer-aided intervention, Odyssey Compass Learning, in the area of mathematics, with a group of nine middle school participants who have moderate to severe ASD. Multiple tools of measure were used and pre-test scores were then compared to post-test scores. Differences were determined. This chapter will review data gathered from this study and a thorough data analysis as well as interpretation will be presented.

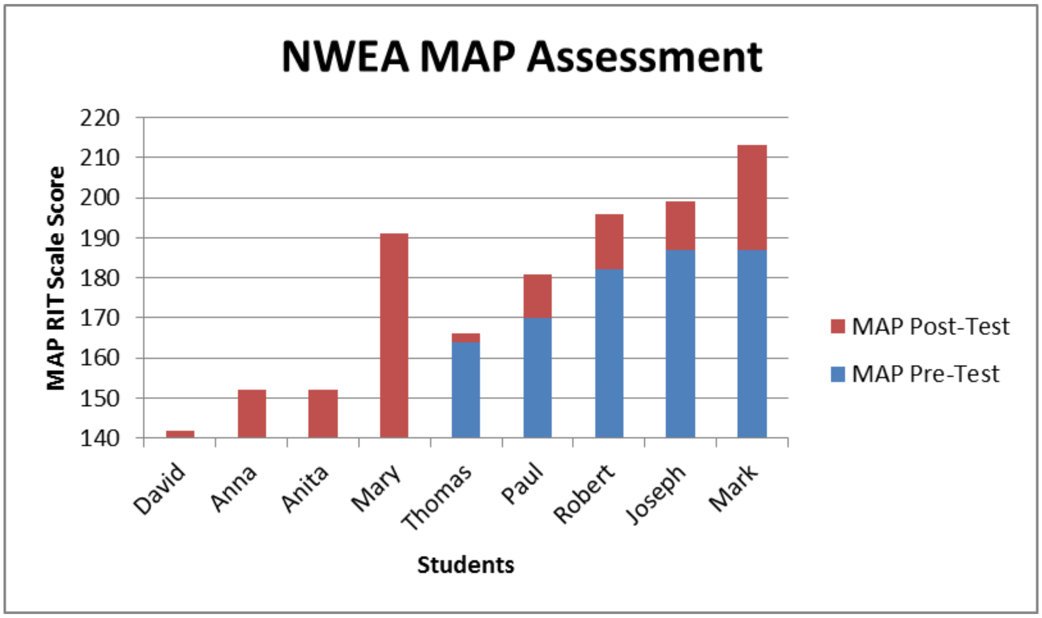
Overall MAP and Number Sense Results

Data from this research study shows that 100% of students demonstrated positive growth after engaging in the computer-aided intervention Odyssey Compass Learning for 30 minutes, two times per week, for 6 weeks, according to both assessment tools used to measure growth. On the Measure of Academic Progress (MAP) RIT scale score, four students scored “too low to measure” on the initial pre-test assessment. Scores from these four students on the post-test MAP RIT are as follows: improved at least 2 points to 142; improved at least 12 points to 152; improved at least 12 points to 152; and improved at least 51 points to 191. It should be noted that the researcher is using the MAP RIT scale score of 140 as a base score, although the actual scores could have been lower and are technically unknown, which is why the phrase “at least” is being used.

Five students were able to generate an initial MAP RIT scale pre-test score. Students from this category improved as follows: initial pre-test 164 with 2 points growth to post-test of 166; initial pre-test score of 170 with 11 points growth to post-test score of 181; initial pre-test score of 182 with 14 points growth to post-test score of 196; initial pre-test score of 187 with 8 points improvement to post-test score of 195: and finally, initial pre-test score of 187 with 26 points improvement to post-test score of 213. Of the four students who were not able to register an initial MAP RIT score, the program was not able to show a growth projection score. Of the five students who generated an initial MAP RIT score, growth projections were that one student would improve 2 points and four student would improve by 3 points. Of these projections, one student only improved by two points with a projected growth of 3 points while three students exceeded their growth projection.

Figure 1 shows a visual representation of the data from the MAP RIT scale score of each student. The blue represents the MAP pre-test scores. Notice that David, Anna, Anita and Mary do not show pre-test scores because their pre-test was “too low to measure”. Only Thomas, Paul, Robert, Joseph and Mark show pre-test data. However, all students showed improvement, represented in red.

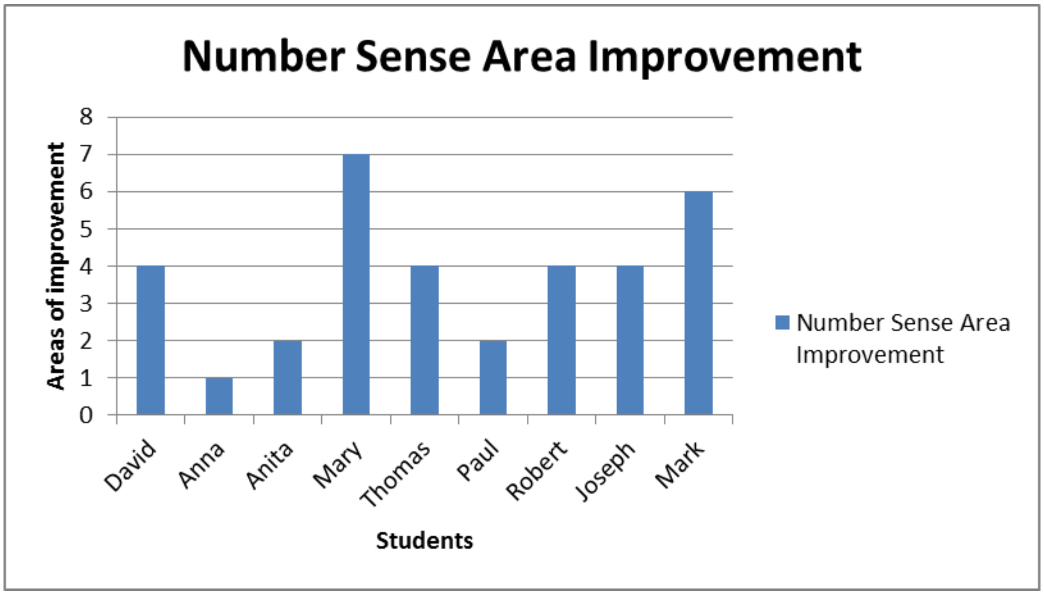
Figure 1. NWEA MAP Results by Student



Two students (David and Thomas) improved by 2 points; one student (Joseph) improved by 8 points, one student (Paul) improved by 11 points, two students (Anna and Anita) improved by 12 points, one student (Robert) improved by 14 points, one student (Mark) improved by 26 points and one student (Mary) improved by 51 points.

When making comparisons between the pre-test and post-test Number Sense and Operation Teacher Inventory rating, the following improvements were found: one student (Anna) improved in one area, two students (Anita and Paul) improved in 2 areas, four students (David, Thomas, Robert and Joseph) improved in 4 areas, one student (Mark) improved in 6 areas and finally one student (Mary) improved in 7 areas. The following graph shows a visual representation of the data from the Number Sense and Operation Assessment of each student.

Figure 2. Number Sense Areas of Improvement by Student



The subsequent section will be a detailed report of each individual research participant and their specific growth as reported from the data according to pre-test and post-test scores of both assessment tools, including projected growth outcomes. The following paragraph will describe in detail the individual data results from each research participant.

Results by Students

David. David's pre-test score was too low to score on the formative MAP assessment therefore, no growth projection was available. However, his summative post-test RIT score was 142 and it is reasonable to assume that 2 points would have been a good growth projection (assuming 140 was the lowest score generated). Comparisons also show that David improved on the Number Sense and Operation Informal Teacher Inventory in four areas from the pre-assessment which include: representing numbers, counting strategies, number patterns and place value. Even though David only showed 2 points improvement on the MAP RIT score, he did improve in 4 areas of the Number Sense and Operation Informal Assessment.

Anna. Anna's pre-test RIT score was too low to score on the formative MAP assessment and therefore, a growth projection was not available. Her summative post-test RIT score was 152, an improvement of at least 12 points, indicating she probably would have exceeded growth expectations based on growth expectations of other students. Comparisons also show that Anna improved on the Number Sense and Operation Informal Teacher Inventory in one area: representing numbers.

Anita. Anita's pre-test RIT score was too low to score on the formative MAP assessment and therefore, a growth projection was not available. Her summative post-test RIT score was 152 with an improvement of at least 12 points, indicating she probably would have exceeded growth expectations based on growth expectations of other students. Comparisons also show that Anita improved on the Number Sense and Operation Informal Teacher Inventory in two areas: representing numbers and estimation.

Mary. Mary's pre-test RIT score was too low to score on the formative MAP assessment and therefore, a growth projection was not available. Her summative post-test RIT score was 191, which indicates significant improvement and it is reasonable to say she would have exceeded any potential growth projection. Anna improved the most out of all students, by at least 51 points. In addition, Mary required almost no accommodations with the intervention. Comparisons also show that Mary improved on the Number Sense and Operation Informal Teacher Inventory in seven areas: number sense, number relationships, number patterns, counting strategies, place value, problem solving-strategies, and computation. Substantial improvement was shown from both assessment tools.

Thomas. Thomas' pre-test RIT score was 164 on the formative MAP assessment. His growth projection was to improve by 3 points. His summative post-test RIT score was 166, which was only a 2 point improvement. While Thomas improved, he did not meet the target growth score projected and is the only student that did not. However, comparisons show that Thomas improved on the Number Sense and Operation Informal Teacher Inventory in four areas: representing numbers, number sense, counting strategies and number patterns.

Paul. Paul's pre-test RIT score was 170 on the formative MAP assessment with a growth projection of 3 points. His summative post-test RIT score was 181, an improvement of 11 points, exceeding his growth expectation. Comparisons also show that Paul improved on the Number Sense and Operation Informal Teacher Inventory in two areas: place value, factors and multiples.

Robert. Robert's pre-test RIT score was 182 on the formative MAP assessment with a growth projection of 3 points. His summative post-test RIT score was 196, an improvement of 14 points, exceeding growth expectations. Comparisons also show that Robert improved on the Number Sense and Operation Informal Teacher Inventory in four areas: representing fractions, identifying fractions, comparing fraction sizes and equivalent fractions.

Joseph. Joseph's pre-test RIT score was 187 on the formative MAP assessment with a growth projection of 3 points. His summative post-test RIT score was 195, an improvement of 8 points, exceeding expectations. Comparisons also show that Joseph improved on the Number Sense and Operation Informal Teacher Inventory in four areas: numbers and patterns, factors and multiples, identifying fractions, and equivalent fractions.

Mark. Mark's pre-test RIT score was 187 on the formative MAP assessment with a growth projection of 2 points. His summative RIT score was 213, an improvement of 26 points, exceeding expectations. Comparisons also show that Mark improved on the Number Sense and

Operation Informal Teacher Inventory in six areas: numbers and patterns, prime and composite numbers, representing fractions, identifying fractions, comparing fraction sizes and equivalent fractions.

Data Analysis and Interpretations

The findings from the data show that all students improved when comparing pre-test scores to post-test scores, on both assessments, while some students improved more than others. The data shows that overall this was an effective intervention, especially since projected growth outcomes were set for “neuro-typical” students and not specifically for students with moderate to severe students with Autism Spectrum Disorder (ASD). While only five students were able to generate an initial score on the standardized MAP assessment, all students were able to generate a score on the summative post-test assessment, indicating that even students with moderate to severe ASD can take a rigorous assessment when provided with proper accommodations.

The research showed that traditionally students with moderate to severe disabilities were assessed in mathematics in the area of functional skills, such as money, and purchasing skills (Browder et al., 2012). This left potential gaps in assessment areas and was a challenge. This research shows that nine students with moderate to severe ASD were able to participate in a rigorous state assessment that was linked to the state’s academic content standards, never before attempted with this particular group of students previously. Not only were they able to complete a standardized computer assessment and intervention, they were able to show improvements in doing so.

Since decisions on how to implement the Common Core State Standards (CCSS) are not made at the Federal level, but rather at the state and local levels and no particular curriculum is mandated, the data from this research shows that the computer-aided interventions, Odyssey

Compass Learning lead to post-test improvements for all research participants. According to the CCSS Initiative (2014) a systematic foundation for acquiring mathematics knowledge is important. The Odyssey Compass Learning program used initial assessment data to provide a systematic, yet personalized learning path for each student that used students' strengths to teach areas of weakness. This research showed that students with significant cognitive disabilities and moderate to severe ASD, might not be able to meet grade level standards, but they most certainly can make progress toward meeting the standards.

Conclusion

The purpose of this research was to ascertain whether the computer-aided intervention, Odyssey Compass Learning, would lead to improved math scores. The data showed that every research participant improved from their pre-test scores to post-test scores on both assessment tools. Participant scores increased between 2 to 51 points on the MAP RIT scale score. In addition, on the Number Sense and Operation Teacher Assessment, students showed improvements ranging from one to seven mathematical number sense areas. Each student progressed individually and showed growth in areas that were weaknesses. Analysis of the data and observations of this study indicate that students with moderate to severe ASD can take a standardized computer assessment, and engage successfully with a computer based intervention when provided with the individual accommodations. The next chapter will provide a personal reflection of the research process with a summary and interpretation of the data along with lessons learned and educational implications. In addition, research limitations and future research direction will be discussed.

Chapter Five: Discussion

Common Core State Standards (CCSS) are a set of high-quality academic standards that dictate what students should be able to do at the end of each grade level. The development of these standards did not include how they should be taught. This led to a diversity of possibilities of how to implement the CCSS. The standards also highlight the importance of providing rigorous, systematic access for students with disabilities. Learners with moderate to severe Autism Spectrum Disorder (ASD) might not be able to achieve grade level benchmarks, but need to be making progress toward meeting the objectives. More research to find effective interventions anchored in the CCSS are needed for this population. As a teacher of nine middle school students with moderate to severe ASD, I wanted to determine whether an individualized computer-aided intervention, Odyssey Compass Learning, would help my students improve in their mathematical number sense skills based on pre- and post- test assessment data. This chapter will present a summary of my research findings with an interpretation of the data. Then I will review lessons that were learned as well as the educational implications from this study. Lastly I will discuss the limitations of the study.

Findings Summary and Interpretations

Findings from this research study revealed that every student showed improvements from pre-test scores on both assessment tools after engaging with the Odyssey Compass Learning Intervention. The first assessment tool was the Northwest Evaluation Association (NWEA) Measure of Academic Progress (MAP). Participant scores increased between 2 to 51 points. Growth projections for the five students that were able to generate initial MAP scale scores were to demonstrate between 2 and 3 points growth. Eight out of the nine students either met or exceeded growth expectations, while one student did not meet the expected growth projection by 1 point, he still improved by 2 points overall after the intervention.

Another way of reporting on the data from the Northwest Evaluation Association (NWEA) Measure of Academic Progress (MAP) post-test scores are that: two students improved by 2 points; one student improved by 8 points, one student improved by 11 points, two students improved by 12 points, one student improved by 14 points, one student improved by 26 points, and one student improved by 51 points. Seven out of nine students showed substantial improvement from pre-test scores.

Scores from the Number Sense and Operation Assessment tool, combined with the Teacher Rating Scale, showed that every student improved in at least one mathematical competency area. Student growth in competency areas from this assessment tool correlated with growth from the Northwest Evaluation Association (NWEA) Measure of Academic Progress (MAP) assessment. Comparisons between the pre-test and post-test scores from the Number Sense and Operation Teacher Inventory Rating assessment showed that students improved from one to seven competency areas. The following improvements were reported: one student improved in one area, two students improved in 2 areas, four students improved in 4 areas, one student improved in 6 areas, and one student improved in 7 areas.

Lessons Learned and Educational Implications

Many lessons were learned through conducting this research. One lesson was how to provide access to the appropriate grade level material for my students within the intervention tool Odyssey Compass Learning. Because I am a middle school special education teacher of students in 6th, 7th and 8th grades, I only had access to grade level material and one grade level below, 5th grade. However, my students required access to K through 4th grade level material. This obstacle was overcome when I learned that because my students took the Northwest Evaluation Association (NWEA), Measure of Academic Progress (MAP) standardized assessment, I was then able to access appropriate grade level material that matched student's needs. All that was required was to enter the program through the NWEA pathway. This was a major lesson learned, without which, almost prevented this study from occurring in the first place. As long as students take the NWEA MAP assessment, they can access appropriate grade level material required for one semester. To continue, they need only take another MAP assessment.

When looking at the Northwest Evaluation Association (NWEA) Measure of Academic Progress (MA) assessment scores for my students, results showed that eight out of nine students met or exceeded growth expectations. Seven out of nine students demonstrated substantial improvements after the initial intervention period. If I were to replicate this study, I would include another cycle of the Odyssey Compass Learning intervention followed by a third MAP assessment in order to see what would happen to the trend in scores during this second cycle of the intervention. I wonder if some of the substantial growth students demonstrated was due in part to the fact that students were more familiar with the actual process of taking the MAP test during the post-assessment. In addition, I speculate that because my students had not been presented with a systematic intervention specifically designed from individual, personalized assessment data, perhaps the rate of learning would level out during the second intervention. This would lead me to wonder if scores would more closely match projected growth rates after the second intervention period. Studies attempting to replicate this research might consider conducting two cycles of the intervention and assessment to answer these questions.

A benefit of the Northwest Evaluation Association (NWEA) Measure of Progress (MAP) assessment tool was that it informed the direction of the intervention individually for each student. This allowed learners to focus on their areas of need, rather than spend time on areas of competence. It helped to fill gaps in knowledge. As a teacher, I do not feel that I would have been able to replicate the growth of each student without this combined assessment and intervention package. Another benefit of the intervention was that it allowed for a lower staffing ratio, while still providing individualized learning. A limitation of the MAP and Odyssey Compass Learning intervention might be its ease of use for students not familiar with computers. In addition, while I did get an overall picture of student's abilities from the NWEA MAP assessment, it did not yield a specific picture of the discrete skill strengths and gaps of my students. However, this information was obtained from the second assessment tool, the Number Sense and Operation K-2 and 3-5 Assessment and Teacher Rating Scale.

A strength of the Number Sense and Operation K-2 and 3-5 Assessment and Teacher Rating Scale was that it provided very good insight into each student's individual concept knowledge. This helped me to identify which students were capable of abstract verses concrete mathematical thinking. This knowledge helped me to develop additional curriculum specific to each student. However, it took a very long time to administer. The post-test assessment took even longer to administer before students topped out at the frustration level. In addition, it was sometimes difficult to alter the question prompt for students with limited to non-verbal abilities. Also, the tool was hard to analyze and was somewhat subjective. I do not recommend using this assessment tool for the purpose of replicating this study. I would however, utilize it as a teacher as an additional tool to assess student knowledge. In addition, I do not believe this research study is less effective without the Number Sense and Operation assessment. However, I do think it enhanced and confirmed the data gathered from the MAP test. Next, I will discuss the intervention Odyssey Compass Learning from the perspective of research about computer assisted instruction (CAI).

According to a study by Traynor (2003), computer assisted instruction (CAI) has been found to provide a context for learning that is challenging, stimulates curiosity and decreasing the cognitive load of the learner's memory allowing other processes to make information relationships. Traynor's study also found that CAI provides animated activities that facilitate engagement increasing student motivation. Students from this research study also appeared to be engaged and motivated when utilizing the CAI Odyssey Compass Learning intervention. Another study found that students with ASD had "fewer problem behaviors" (Ramdoss et al., 2011, p. 73) when engaging in CAI. I also found this to be true based on observations of the research participants as behaviors and distractions were reduced while students were engaging with the intervention. In addition, students appeared to benefit from clear routines and expectations when engaging with the program. Overall, student not only improved in mathematical concepts, (based on data), but also seemed to enjoy engaging with the intervention. It appears that Odyssey Compass Learning was an effective computer-assisted instruction (CAI) intervention for mathematics for these students with moderate to severe Autism Spectrum Disorder (ASD) based on the data analysis of this research.

Limitations of Research

One limitation of this study was that the sample size was low. In addition, while the Number Sense and Operation K-2 and 3-5 Assessment and Teacher Rating Scale provided very good insight into my individual student's concept knowledge, it took a very long time to administer. This was a challenge. In addition the tool was somewhat subjective.

Another limitation of this study is that while students from this study showed improvements, the research cannot be generalized to all students with Autism Spectrum Disorder (ASD) as each student with ASD is different. In addition, all students had some familiarity with using computers, so this study might be hard to replicate if students do not have this pre-requisite skill.

Future Research Directions

Research is building for effective evidence-based practices for students with Autism Spectrum Disorder (ASD). One evidence-based intervention is computer-aided instruction (CAI) and is supported as a best practice for increasing student engagement and learning (Browder et al., 2012). In addition, literature related to teaching mathematics for students with ASD is “limited in both quantity and scope” (Browder et al., 2012, p. 27). According to the CCSS Initiative, Mathematical Standards, Application to Students with Disabilities (2010),

> The continued development of understanding about research-based instructional practices and a focus on their effective implementation will help improve access to mathematics and English language arts (ELA) standards for all students, including those with disabilities (para. 2).

The positive results from this study will help to build on the present body of research available in the field. It is relevant for Education Specialists who teach students with moderate to severe ASD. It addresses challenges for providing an individualized, assessment based curriculum that meets common core state standards. Research in mathematics for severely cognitively impaired students and students with ASD has been heavily related to mathematical functional skills and limited. The significance of this research is that the computer-based intervention is directly linked to standardized assessment data that connectss to an intervention that systematically exposes students to Common Core State Standards (CCSS). The positive results from this math intervention may encourage special education teachers to attempt the standardized Northwest Evaluation Association (NWEA) Measure of Academic Progress (MAP) assessment and companion CAI Odyssey Compass Learning intervention. Research by Knight, Smith, Spooner & Browder (2011), states that "as the focus on access to the general education curriculum continues for students and teachers of students with ASD and other developmental disabilities, insight in how to discover, refine, and impart evidence-based practices for this population will become increasingly important" (p. 388).

Summary/Conclusion

Common Core State Standards (CCSS) provide the opportunity to improve access to rigorous academic content in the area of mathematics for students with disabilities. However, how to implement the standards was not mandated. The purpose of this study was to determine if the computer-aided instruction (CAI) intervention, Odyssey Compass Learning, would improve math outcomes for students with moderate to severe Autism Spectrum Disorder (ASD). Research participants included nine middle school students from a special day class in Southern California with moderate to severe (ASD). Characteristics of autism and how they relate to learning were established. Research was presented on Common Core State Standards (CCSS), evidence-based practices (EBP) and computer-aided instruction (CAI). Research found that the focus on access to the general education curriculum continues for students and teachers of students with ASD. Research by Knight, Smith, Spooner & Browder (2011) found that "insight in how to discover, refine, and impart evidence-based practices for this population will become increasingly important" (p. 388). The participants and setting were described in rich detail along with the research instruments and procedures. Pre-test scores were obtained and compared to post-test scores and differences were measured. The data showed that every research participant improved from their pre-test scores to post-test scores on both assessment tools. Participant scores increased between 2 to 51 points on the MAP RIT scale score with seven of the nine participants showing substantial improvements. In addition, on the Number Sense and Operation Teacher Assessment, students showed improvements ranging from one to seven mathematical concept areas. Analysis of the data and observations of this study indicate that the students with moderate to severe ASD from this study were capable of taking a standardized computer assessment. They were also able to successfully engage with a computer based intervention when provided with accommodations. A reflection of the research was provided along with an interpretation of the data. Lessons learned and educational implications were reviewed. In addition, research limitations and the direction of future research was discussed. The data from this research showed that the Odyssey Compass Learning intervention was an effective computer-assisted instruction (CAI) intervention for mathematics for students with moderate to severe (ASD). It is the hope of this researcher that the positive data from this study will lead to more students with moderate to severe disabilities being exposed to standardized assessments with companion CAI interventions such as Odyssey Compass Learning.

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