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THE EFFECTS OF GONOODLE ENGAGEMENT ON MATHEMATICS SKILLS OF MIDDLE SCHOOL-AGED STUDENTS WITH AUTISM

Cheryl D. Barrett
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THE EFFECTS OF GONOODLE ENGAGEMENT ON MATHEMATICS SKILLS OF
MIDDLE SCHOOL-AGED STUDENTS WITH AUTISM

By

Cheryl D. Barrett

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In Partial Fulfillment of the
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Stockton, California

2023

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By

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THE EFFECTS OF GONOODLE ENGAGEMENT ON MATHEMATICS SKILLS OF
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By

Cheryl D. Barrett

Dedication

This dissertation is dedicated to Frank James Duclo, Jr. in honor of his support and encouragement for me to continue with my education, which he expressed during the speech he delivered on my wedding day. Always missed but never forgotten, rest in peace, sweet brother.

Acknowledgment

In the beginning of my program, the professors always alluded to obtaining one's doctorate was like climbing a mountain. During the climb, some people might go straight up the mountain making huge gains quickly, while others tend to go circles around the mountain only making small gains but always moving towards the top. I was with the others moving around the mountain for a long time. It was not until I lost my brother that I decided to start moving up that mountain. In making that move, many people in my life sacrificed our time together, provided words of encouragement, and never let me forget what I was striving for. For these reasons and many others, I give my gratitude and thanks to family, friends, and associates.

For my husband, Bryan Barrett, and his gracious support and encouraging notes, he left at my workspace. We have been married for 5 years and the whole time you have been by my side while I typed away for countless hours. You always let my dissertation come primarily without hesitation or disappointment. Your dedication to my success has been a blessing. Thank you for supporting me endlessly in all our adventures together.

For my mother, Michele Montgomery, and her unconditional love. Mom, you have been my cheerleader throughout my entire life. Without your compassion, protection, and the importance of family, I would not have become the person I am today; one who strives for greatness and togetherness through compassion. Thank you for always being there for me no matter my endeavors.

For my father, Frank Duclou, Sr., and his lofty expectations for his children to succeed in life. You always made sure I had goals and ambitions for my future self. You expressed the

importance of education, and I took that to heart. Thank you for instilling in me excellent work ethics, dedication, and the will to finish what I start.

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THE EFFECTS OF GONOODLE ENGAGEMENT ON MATHEMATICS SKILLS OF MIDDLE SCHOOL-AGED STUDENTS WITH AUTISM

Abstract

By Cheryl D. Barrett

University of the Pacific
2023

Academic achievement of students with disabilities has long been a concern in special education, and this work addresses the academic achievement gap between students with autism spectrum disorder (ASD) and their typically developing peers. This study aimed to increase mathematical achievement in fluency and calculation skills for students with ASD using GoNoodle. Additionally, this study intended to extend evidence about existing research on the efficacy of GoNoodle as an appropriate academic intervention tool for students with disabilities.

Participants of this study were middle-school-aged students with autism as a primary diagnosis. Extant data was used for this study and the researcher established protocols and data collection tools to increase fidelity in the intervention procedures. During intervention sessions, participants were rated on a 4-point Likert scale with a score of 1 being 'no participation' (i.e., the participant chose to not participate and sit at their desk instead); a score of 2 being walking in place only; 3 being running in place only; 4 being both walking and running in place during each segment of the intervention. Their WJ-IV fluency and math calculation tests measured participants' mathematical achievement.

Results of this study derived from descriptive analysis, paired samples t-test, Pearson's product-moment correlation, and social validity survey. Descriptive analysis assisted with grouping participants into ASD classification levels. Results showed the numbers of students in

each ASD classification level were uneven, therefore excluded from further analysis. The paired sample t-test provided a mean difference between the three timeframes for the *WJ-IV* scores.

Participants showed an increase in the pre-mid (medium effect size) and pre-post (large effect size) timeframes, but a decrease during the pre-mid timeframes. Pearson's results were all found to be not statistically significant when considering GoNoodle to have an impact on mathematical achievement. Scores did improve, but not enough for statistical significance. Finally, a social validity survey analyzed participants' perceptions of the use of GoNoodle to ascertain the value of the online tool. Analysis indicated that 100% of the participants provided a positive response to the GoNoodle Mega Math Marathon intervention being fun ($n = 25$) and an overall positive response (88%) to the intervention tool in general ($n = 22$). 92% of the participants indicated that they would like to do more GoNoodle activities, thought it was exciting and enjoyable, and felt that they learned new math skills after engaging in the intervention ($n = 23$). Moreso, 88% of the participants had a positive response to feeling healthier after engaging with the GoNoodle Mega Math Marathon program ($n = 22$).

This tool proved to be a promising strategy for students to be engaged, interested, and excited about learning mathematical skills within this specific population of participants. More research is needed to address the educational gap and to provide better opportunities for living a healthy lifestyle and building an era of productive members of society.

Table of Contents

List of Tables	13
List of Figures	14
Chapter 1: Introduction	15
Background	15
Overview of Autism Spectrum Disorder (ASD)	17
Overview of Academic Achievement of Students with ASD	19
Incorporating Exercise and Movement (EXM)	21
Statement of Problem	22
Purpose of Study	25
Research Questions and Hypothesis	26
Significance of the Inquiry	27
Chapter Summary	29
Chapter 2: Literature Review	30
Introduction to Literature Review	30
History of IDEA	30
Free Appropriate Public Education (FAPE) and Provision of Services	33
Least Restrictive Environment (LRE)	34
Individualized Education Program (IEP) for Students with Disabilities	35
Who are Students with Disabilities (SWD)?	35
Background and Severity of Autism Spectrum Disorder (ASD)	36
Severity Levels of Autism Spectrum Disorder	38

	10
Level 3: Requiring Very Substantial Support	39
Level 2: Requiring Substantial Support	39
Level 1: Requiring Support	39
Importance of Levels of Autism	40
Current Mathematical Performance for Students with Disabilities	41
Effective Practices in Supporting Mathematical Achievement for Students with ASD	43
Effect of Exercise and Movement (EXM) on Students with ASD	44
EXM and Academic Achievement for Students with ASD	46
EXM as an EBP	47
Technology-Aided Instruction and Intervention (TAII) and Students with ASD	49
Chapter Summary	50
Chapter 3: Methods	51
Quantitative Correlational Research Design	51
Quantitative Correlational Research Questions	52
Inquiry Approach	53
Purpose and Appropriateness	55
Methodology	55
Teacher-Researcher Role	56
Instrumentation	58
Woodcock Johnson-IV Tests of Achievement	58
GoNoodle	60
Description of Participants	67

	11
Data Sources	69
Intervention Procedures	69
Data Analysis	72
Ethical Considerations	76
Threats to Validity	76
Assumptions and Limitations of the Study	77
Chapter Summary	78
Chapter 4: Findings	79
Outcomes and Analysis of Research	79
Descriptive Analysis Results	80
Paired Samples T-Test	81
Tests for Assumptions: Outliers	83
Tests for Assumptions: Normality	87
Paired Samples T-Test Final Results	88
Pearson's Product-Moment Correlation	89
Tests for Assumptions: Linearity and Outliers	90
Tests for Assumptions: Normality	91
Social Validity Pre- and Post-Survey Results	93
Chapter Summary.....	95
Chapter: Discussion, Conclusion, and Recommendations	98
Implications of Findings	98
Summary and Interpretation of the Findings	99
Research Question 1	100

	12
Research Question 2	101
Research Question 3	101
Research Question 4	101
Implications	102
Limitations of the Study.....	105
Recommendations and Future Research	107
Chapter Summary	109
References	111
Appendix A	136
Appendix B	137
Appendix C	140
Appendix D	142
Appendix E	145

List of Tables

Table

1. Summary of Reviewed GoNoodle Research Findings	65
2. Participant Demographic	68
3. ASD Classification	81
4. Overview of Outliers	84
5. Wilcoxon Signed Rank Test Hypothesis Summary	86
6. Shapiro-Wilk Test Results for Calculation Scores	87
7. Pearson's Correlation Test Results	92
8. Effect Sizes	100

List of Figures

Figure

1. Legislative Mandates in Summary	32
2. Examples and Nonexamples of EXM	53
3. Teacher-Created Intervention Procedures	71
4. Social Validity Survey Questions	75
5. Obtaining a Difference Score	82
6. Students' Self-Rated Responses on the Pre- and Post-Survey	94
7. Students' Self-Rated Responses on the Post-Survey	95

CHAPTER 1: INTRODUCTION

Background

The Individuals with Disabilities Education Act's (IDEA) federally mandated Free and Appropriate Public Education (FAPE) provision guarantees special education services for eligible students with autism spectrum disorder (ASD) (Individuals with Disabilities Education Act [IDEA], 2004a). IDEA (2004) protects the rights of children with disabilities and their families, assists agencies in providing an education for identified students, ensures educators and parents can access and obtain the appropriate tools necessary to improve educational outcomes and assesses the efforts and effectiveness of these children (IDEA, 2004a).

An individualized education program (IEP) for all eligible students is established through Section 1414 (d) of IDEA, to identify areas of need and guide schools and educators in providing meaningful and beneficial education to students with disabilities (2004b). An IEP is created by an IEP team (usually composed of the student, family or guardian, and various school-based staff and faculty members) to identify student needs and determine the Least Restrictive Environment (LRE) under IDEA. The IEP team must carefully consider the student's LRE as the team's decision impacts not only where students spend a percentage of their time in schools but also how special education services will be rendered (IRIS, 2019). Per IDEA, school districts are responsible for establishing a continuum of alternative placement options ranging from least restrictive to most restrictive. LRE decisions are not made lightly due to the federal requirements and subsequent legal implications. The IEP team may remove a student from the generalized educational environment if the severity of the disability impedes the learning of

others and self, and supplementary services and aids have not shown useful in achieving academic satisfaction (IDEA, 2004c).

The academic achievement of students with disabilities (SWD) has long been a concern in the field of special education (Bouck & Flanagan, 2009; Klehm, 2014; Schulte & Stevens, 2015). Historically, SWDs have underperformed in all facets of academic engagement compared to their same-aged peers with disabilities (Greer, 2011). When aggregated by the 13 IDEA disability categories, student performance is known to worsen. For example, students with high-incidence disabilities tend to perform very low with mean values at or below basic performance (Gage et al., 2012; IDEA, 2004d). High-incidence disabilities refer to students whose IDEA-disability category comprises a high percentage of the general IDEA-population; high-incidence disabilities are most prevalent among students with emotional and behavior disorders, learning disabilities, and mild intellectual disabilities; these students are typically taught in a general education environment (Gage et al., 2012). Similarly, students with low-incidence disabilities perform and learn at rates well below those of their peers without disabilities (Brown & Brinkman, 2004). Low-incidence disabilities refer to students whose IDEA-disability category comprises a small percentage of the greater IDEA-population. Such cases are most prevalent among children with visual impairment or hearing loss, deaf-blindness, significant cognitive impairment and “any impairment that requires individualized intervention services for the child to benefit from his or her education including individuals with autism, traumatic brain injuries, orthopedic impairments, or multiple disabilities” (iresearchnet, 2016). Moreover, students with low-incidence disabilities are taught in separate settings (outside of general education) for most of their school day and are instructed according to their IEP goals which can be geared towards

functional life skills and functional academic skills as well as relating to the general education academic skills (Collins et al., 2005).

Overview of Autism Spectrum Disorder

ASD is defined as “a complex developmental condition that involves persistent challenges in social interaction, speech and nonverbal communication, academic development, and restricted/repetitive behaviors” and is one of the disability categories covered under IDEA (2004) (APA, 2013; IDEA, 2004d). Individuals with ASD may present difficulty with social skills which can manifest as anxiety leading to poor relationships, social isolation, and withdrawal from others (Howse, 2019; White & Roberson-Nay, 2009). Although attention and working memory are not diagnostic features of ASD, they are consistently reported areas of atypical cognitive development associated with ASD (Ames & Fletcher-Watson, 2010). The effects of ASD and the severity of symptoms are different in each person and range from three levels in severity (APA, 2013).

ASD is known to be the fastest-growing developmental disability in the United States (AutismSpeaks, 2022; Wertheim & Apstein, 2016). As of March 2020, it is estimated that ASD affects one in 54 individuals in the United States today which is a 10% increase from the previous rate of one in 59 individuals (Autism Research Institute [ARI], 2020). Reasons for the fast growth of ASD are the expanded definition of autism, heightened awareness, increased state-financed support, and early intervention programs (Wertheim & Apstein, 2016). ASD is still considered to be a low-incidence disability affecting a small percentage of the general IDEA population, despite the growth in diagnosis (iresearchnet, 2016).

ASD includes different subtypes and varies in severity from mild to severe, or somewhere in between, thus leading to a spectrum of the disorder (Stoia et al., 2020;

AutismSpeaks, 2022). Children with ASD may present difficulties in four general areas: (a) speech, language, and communication; (b) relating to people, objects, and events; (c) responses to sensory stimuli; and (d) developmental discrepancies (Konukman et al., 2017). Since the severity of symptoms presented in the disability varies from individual to individual, students with ASD may exhibit variable needs in accessing the educational environment and academic materials. In school, students with ASD tend to need additional support (i.e., 1:1 paraprofessionals, visual icons and schedules, additional processing time, fidgets) to participate in the generalized classroom. Students with ASD with significant needs may best be taught in specialized settings called a Specialized Day Class (SDC). An SDC is a term used to describe a “self-contained special education class which provides services to students with intensive needs that cannot be met by the general education program, RSP (Related Service Provider) or Designated Instruction Services (DIS) program” (Understanding Special Education, 2019). SDC settings are beneficial to students with ASD who require elevated levels of support in academic and social areas that cannot be effectively delivered in the generalized educational setting. However, these academic and behavioral supports eventually affect an individual’s lifestyle, partly due to not being involved in the traditional classroom (Rotheram-Fuller et al., 2010).

Students in SDC settings are typically receiving academic and related services in a specialized setting for more than 50% of the school day (Understanding Special Education, 2019). Students with ASD enrolled in an SDC have are placed in that setting according to decisions made by their IEP teams. These students are identified as needing specialized services and additional support to be successful in meeting their educational goals and achievements. The SDC is considered their LRE and provides services to address intensive needs and challenges, in social communication, social interaction, behavioral concerns, and/or academic

development, which cannot be met in general education programs (Understanding Special Education, 2019). The SDC settings are designed to have small student-to-staff ratios and incorporate Evidence-Based Practices (EBP) for students with ASD (Stockton Unified School District [SUSD], 2022a; United Federation of Teachers, 2022). EBPs are defined by a systematic approach which is “supported by a sufficient number of research studies that (a) are of high methodological quality, (b) use appropriate research designs that allow for assessment of effectiveness, and (c) demonstrate meaningful effect sizes such that they merit educators’ trust that the practice works” (Cook et al., 2012). Such EBPs may include video modeling, visual support, reinforcement, naturalistic interventions, and technology-aided instruction and intervention (Steinbrenner et al., 2020; National Autism Center [NAC], 2020). Together, IDEA and district-provided special educational services are meant to support the academic achievement of students with disabilities.

Overview of Academic Achievement of Students with ASD

Educational outcomes for students with ASD are highly variable, though they have been reported as low-performing (Keen et al., 2016). Students with ASD who have higher IQ scores tend to perform better on academic measures and students with more social and behavioral needs tend to perform worse (Eaves and Ho, 1997; Keen et al., 2016; Manti et al., 2011). It is estimated that 33-65% of students with ASD present difficulty with reading (Jones et al., 2009; McIntyre, Solari, Grimm, et al., 2017; McIntyre, Solari, Gonzalez, et al., 2017,) and 15 to 40% present difficulty in math (Estes et al., 2011; Jones et al., 2009). Wei et al. (2015, 2017) studied the reading and math achievement profiles and longitudinal growth trajectories of students with ASD and found they perform about one standard deviation below the national average compared to their same-aged peers without disabilities on all academic measures. The researchers also

identified four achievement profiles within the ASD population that show varied academic performance does indeed exist when aggregated by level of student need.

A large body of research focuses on the advanced mathematical abilities of some individuals with ASD present (see: Peklari, 2019). However, contrary to the belief that students with ASD are naturally mathematically gifted, these students tend to have deficits in many mathematical areas including calculation skills and fluency (Oswald, et al., 2016). As it stands, little has been found on the mathematical achievement of individuals with ASD who have more significant support needs. While the SDC setting may be the LRE for these students, it may also exclude them further from the general education classroom and experience. As a result, they fall further and further behind, making it difficult, if not impossible, to ever catch up to their typically developing peers or graduate high school with a diploma (Klein, 2017). Regardless of the level of severity, one thing is made very clear, the gap in grade-level and academic achievement between students with ASD and students without disabilities is significant enough to require devoted attention, time, and resources to identify effective teaching and learning methods designed to support students with ASD (Gilmour et al., 2019; Ji, 2018; Keen, Webster, & Ridley, 2016).

The demand to close the gap between grade-level achievement and academic achievement is growing (Alkharusi et al., 2010). Since the COVID-19 pandemic, online resources are increasingly used to support educational growth (Alabdulaziz, 2021). The use of modern technology has been successful to help people with ASD learn a variety of skills (Valencia et al., 2019). There is reason to believe in the potential for improving mathematical achievement using online resources for students with ASD from reviewing past research (Anderson-Haley et al., 2011; Bittner et al., 2018). For example, a study consisting of 2,850

seventh-grade students on the use of an educational technology intervention found that mathematical achievement was higher for students who used an online resource than those who were business as usual (Roschelle et al., 2016). When learning something new, technology can be a highly fascinating and beneficial tool to use with children with ASD, versus traditional methods of learning (Tashnim et al., 2017). While technology is being incorporated in many ASD-related studies, the use of online resources to enhance instruction for students with ASD who have significant learning and behavioral needs has not been explored at length.

Incorporating Exercise and Movement

There is also substantial evidence that suggests incorporating exercise and movement (EXM) into the learning environment could improve academic achievement for students with and without disabilities (Duke, 2018; GoNoodle, 2013; Wold, 2019). Results from fitness and achievement scores of more than 1 million California students showed that scores were consistently higher for kids who engaged in movement (Grissom, 2005; Reilly et al., 2012). GoNoodle is a free online resource available for teachers that includes activities and games, like Mega Math Marathon and Ultimate Champ Training, which incorporate movement and other elements of EXM in the learning experience. Only a handful of studies have used GoNoodle, and findings show a variety of outcomes. For example, Lotta (2015) found that after movement breaks using GoNoodle, students' grades did not improve and that students had a more challenging time settling down after the movement break due to feeling less tired. A GoNoodle study with 377 sixth-grade students focusing on improving mathematics fluency and English literacy, found that the intervention helped with students' attitudes towards school but did not improve either academic area (Duke, 2018). However, despite previous studies, Wold (2019)

found that using GoNoodle movement breaks as an EXM did improve reading fluency for second and third-grade students.

Relatedly, in a 2020 study, McDougal et al. found attention to be a contributing factor in academic achievement of children with ASD. The researchers affirmed that children with ASD who have poorer attention and achievement (as measured by standardized achievement tests) displayed relative weaknesses in mathematics while children with average or above-average attention and achievement showed no such weaknesses. EXM has shown improvement for students with ASD with a longer duration of attention span on the attention task as the number of exercise sessions increases (Tan, 2011). The implementation of an online resource which provides movement breaks along with mathematical equations, like GoNoodle, could provide additional evidence to establish EXM as an EBP for students with ASD in an SDC to strengthen mathematical skills. Additionally, implementation could serve as a resource to improving movement, decreasing academic deficits and behaviors and support student progression towards obtaining a high school diploma and a healthy lifestyle (Reilly et al., 2012). Together, these ideas of online resources for movement and academic gains provide students with an opportunity to enhance mathematical skills, while simultaneously being motivated by technological instruction (GoNoodle, 2013)

Statement of Problem

Free and appropriate public education (FAPE) in the least restrictive environment (LRE) must be provided to all students with disabilities (SWD), including autism spectrum disorder (ASD), according to legal requirements spelt out in IDEA (2004a, b). Such services help to provide meaningful and beneficial educational experiences for improved in-school and post-school outcomes. Studies that aim to improve academic achievement and growth for students

with ASD who are in the general education setting, have been conducted (Bae et al., 2015; Estes et al., 2011; Fleury et al., 2014; Kamps et al., 1989). For students with ASD who are taught in an SDC more than 50% of their day, studies tend to focus on identifying and using effective practices to teach functional, behavioral, and academic skills related to functional living (Collins, et al., 2005; Kirk, 2013; Kopetz & Endowed, 2012; Spencer, 2009). While these are indeed key areas for individuals with ASD who have significant support needs, their academic achievement and growth have not been an area of focus. This is an increasingly worrisome problem in the field as challenges with cognitive achievement are a primary concern for students with ASD and enrolled in an SDC. There exists a gap in the literature about how to reduce these concerns and increase cognitive achievement.

Narrowing the focus of the problem further, middle school-aged students with specialized needs and primary disability diagnosis of ASD, taught in an SDC within one school district in Northern California, Stockton Unified School district (SUSD), have, historically, presented difficulty meeting grade-level standards in mathematics. In accordance with IDEA's (2004) directive to place SWD in their respective least restrictive settings, SUSD lists 12 steps to follow when making LRE decisions in their special education policy and procedures manual (SUSD, 2022b). Within SUSD, SDCs may be specially designated as *Special Day Class – Autism* (SDC-AUT) defined as:

K-8 students demonstrating deficits in the area of Communication, Social Skills and behavior often related to Autism are served by SDC-AUT programs. These programs may include EBPs such as Discrete Trial Training, physical and visual supports, Picture Exchange Communication Systems, Social skill stories, and Sensory Integration throughout the day (2022).

Students in SDC-AUT classes present additional difficulty in meeting the district's initiative to have higher graduation rates for all populations (SUSD, 2022c). This is evidenced by the designation of "very low" scores on the 2020 i-Ready math diagnostic used in the district (California School Dashboard, 2019). The i-Ready diagnostic has been used in SUSD to assess California common core state standards for mathematics. This population of students in SUSD are at least three grade levels behind their grade/age group and although taught in an SDC, they are expected to meet grade-level standards and take the state academic tests in core subjects, including mathematics. The drastic disparities between grade-level achievement and academic achievement in an SDC could potentially hinder the student's ability to be a part of mainstream education, obtain a high school diploma rather than a certificate of completion, and live a quality life. Despite this, there is limited research on students with ASD placed in an SDC for more than three years of their academic school experience and the connection between their engagement with online resources and mathematical achievement. Therefore, there is a growing need for studies to identify additional EBPs, interventions, and strategies aimed at improving the mathematical achievement of middle school-aged students with ASD in an SDC (Oswald et al., 2016).

The incorporation of technology and online resources is known to support the learning of students with and without disabilities (Flynn & Richert, 2018; Lei & Zhao, 2007; Morgan, 2014). Similarly, incorporation of physical movement is known to support academic performance and engagement (Elleberg & St-Louis-Deschenes, 2010; Tomporowski et al., 2008). While use of online resources to support the academic growth and achievement of students with ASD have been studied to a degree (Anderson-Hanley et al., 2011; Flynn & Richert, 2018; Langhorne, 2017), and some studies have been conducted on integration of EXM with students with ASD

(Nicholson et al., 2011), no studies were found connecting the free online resource, GoNoodle, and its impact on mathematical achievement of middle school-aged students with ASD in an SDC.

Purpose of Study

The purpose of this study is two-fold. First, the study aims to examine the correlation between an online resource, GoNoodle, that integrates EXM with mathematical achievement for middle school students with ASD enrolled in an SDC within SUSD. Although the SDC setting is identified as the most appropriate setting and LRE for the students in the study, their separation from the general education settings contributes to the academic achievement gap between students with and without disabilities. The students included in this study are at least three grade levels behind their same-aged peers without disabilities and display significant deficits in mathematical achievement. Therefore, I will explore if the integration of GoNoodle's Mega Math Marathon contributes to improved academic achievement of middle school students with ASD.

Second, given the pressing need to close the gap in the academic performance of students with and without disabilities, including ASD (NAEP, 2019), identifying new and/or confirming known EBPs for students with ASD who require significant support is of utmost importance. To that end, I sought to add to and expand current research on EXM as an EBP in mathematical academic achievement and growth for students with ASD. Currently, EXM has been identified as an EBP by the National Clearinghouse on Autism Evidence-Based Practice (NCAEP) but only as an emerging EBP by the National Standards Project (NAC, 2015; Bittner, et al., 2017). While there have been studies conducted on EBPs and cognitive ability with non-typically developing

students focusing on a variety of skills, none are found on the use of online resources to improve mathematical achievement for students with ASD (Steinbrenner et al., 2020; NAC, 2009, 2011).

The study research questions, the purpose of the proposed inquiry, and the significance and rationale of this study are in the sections below. The following chapters offer descriptions of related background information about ASD, mathematical achievement for typically developing students and students with ASD, and EBPs for persons with ASD related to this study.

Research Questions and Hypothesis

The following research questions guided this study:

1. Do the math fluency and calculation scores of middle school-aged students with ASD improve over time after engaging with the GoNoodle Mega Math Marathon intervention?
2. Is there a correlation between math fluency scores and level of ASD, days of exposure, time engaged, and variation of movement for students with ASD who interact with the GoNoodle Mega Math Marathon intervention?
3. Is there a correlation between math calculation scores and level of ASD, days of exposure, time engaged, and variation of movement for students with ASD who interact with the GoNoodle Mega Math Marathon intervention?
4. How do students with ASD respond to the GoNoodle Mega Math Marathon intervention as a tool to improve math skills?

Considering the students included in this study are more than three grade levels behind their same-aged peers and substantial evidence shows positive gains in mathematical skills by use of technology in children with ASD, as well as through means of EXM (Elleberg & St Louis Deschenes, 2009; Munoz et al., 2018; Tashnim et al., 2017), I hypothesize that students with higher levels of involvement in the GoNoodle program will significantly improve students' mathematical fluency skill and calculation achievement.

Significance of the Inquiry

This study will examine the correlation between EXM and mathematical achievement for middle school-aged students with ASD through an online resource, GoNoodle. This study focuses on students with ASD who are in an SDC setting and require continuous and engaging methods of instruction to support their mathematical achievement progress as it is currently low and identified as a high area of need within the district and school environment. The significance of this inquiry is two-fold.

First, the study results will contribute to the knowledge base of using technology and movement as an EBP for students with ASD. EBPs require ongoing collaboration and interactions between all stakeholders (NAC, 2009). Identifying EXM as an EBP, has had minimal research (Dillon et al., 2017). The NCAEP identifies EXM as an EBP, yet the National Standards Project (2015) only identifies EXM as an emerging intervention (National Professional Development Center [NPDC], 2014; Steinbrenner et al., 2020). Both organizations have identified technology as an EBP. Currently, Technology-Aided Instruction and Intervention (TAII) is instruction or intervention in which technology is the central feature and specifically designed or employed to support the learning or performance of a behavior or skill for the learner (Steinbrenner et al., 2020). The involvement of an online resource which emphasizes EXM may yield a positive relationship with mathematical achievement in students with ASD enrolled in an SDC (Roschelle et al., 2016). This study utilizes the GoNoodle program, which combines short bursts of EXM with mathematical problems, adding fun and building brainpower to learning, for students in grades kindergarten through fifth grade (GoNoodle, 2013).

Second, the benefits of incorporating effective online resources for students with ASD range from personal interests to educational gains to lifestyle management. Positive study results

will significantly benefit teachers at middle school students with ASD and students with ASD who participate in the study and their families. Though there are numerous online resources available for teachers at middle school students, very few, if any, are designed for students with ASD in SDC settings. Positive results of this study will show how EXM paired with mathematical problems increases mathematical fluency and calculation skills for middle school students with ASD, enrolled in an SDC. Teachers could then confidently use the online resource to support increased mathematical achievement for their students while also supporting increased healthy physical activity, overall academic engagement, and well-being. Based on the study results, information on the importance of EXM and the overall wellness of the child will be disseminated to the educators, students, and families to increase awareness of the positive effects of EXM on math achievement. This could lead to specially designed online programs for children with ASD using said strategies and support current research on technology and movement being identified as an EBP. Additionally, results from this study may warrant advancements for SDCs to promote EXM in association to academic skills within their programs.

Incorporating short bursts of EXM routines into a student's daily schedule may also lead to healthier lifestyles. This is an important benefit to student participation in the study because, overall, students with ASD tend to move less, be overweight, and be more than 3 years behind academically (Alkharusi et al., 2010). The level of engagement required of students in this study will address all these areas of need. To show the efficacy of incorporating EXM through technology-based games, data were shared with families of students during and after the study period. Data pertaining to the correlation between EXM and mathematical achievement will encourage families of students with ASD to use an online resource outside of the school to assist

their children with higher academic achievement and increased EXM for the benefit of health gains. Throughout the study, students also indicated their perceptions of using GoNoodle which informed if they found value and fun in the tool. Student perception is a significant factor in their level of engagement and impacted the usefulness of the online resource. Students who enjoyed the use of the online resource were encouraged to continue its use in and out of the classroom which in turn, may help increase their mathematical achievement.

Chapter Summary

Given that (a) ASD is the fastest-growing developmental disability in the United States (AutismSpeaks, 2022; Wertheim & Apstein, 2016), (b) school districts are required to provide a FAPE to children with special needs, (c) more research is needed to establish EXM as an EBP for students with ASD, and (d) students with ASD in SDC settings are academically behind and engage in less physical activity than their typically developing peers, incorporating a free online resource that addresses all of these areas is a crucial need in supporting the mathematical achievement of students with ASD. The information from this study will benefit localized communities, teachers, and students/families, in being able to incorporate EXM opportunities with a focus on increasing mathematical achievement among students.

The following chapter will review pertinent literature related to this study regarding the legal requirements of providing special education services to students with ASD, a description of the levels of autism, the current achievement in mathematics of students with disabilities, and the impact of EXM and technology on achievements.

CHAPTER 2:LITERATURE REVIEW

Introduction to Literature Review

It is necessary to analyze how movement paired with mathematical problems using technology increases the mathematical fluency and calculation skills to work towards closing the academic achievement gap for middle school students with autism in a specialized day class (SDC). This literature review discusses the background and severity of autism for those in an SDC setting, mathematical achievement of students with autism spectrum disorder (ASD) versus their typically developing peers, how movement is associated with higher academic achievement in mathematics, the use of technology for students with ASD, and why students with ASD tend to participate in movement less than their typically developing peers.

History of IDEA

As described in Yell et al. (1998) summary of the long and at times, strange, history of special education, Senator Harrison Williams stated the following in his congressional bill proposal to provide federal funds for the education of students with disabilities (SWD):

“We must recognize our responsibility to provide education for all children [with disabilities] which meets their unique needs. The denial of the right to education and to equal opportunity within this nation for handicapped children—whether it be outright exclusion from school, the failure to provide an education which meets the needs of a single handicapped child, or the refusal to recognize the handicapped child's right to grow—is a travesty of justice and a denial of equal protection under the law. ” (p. 225).

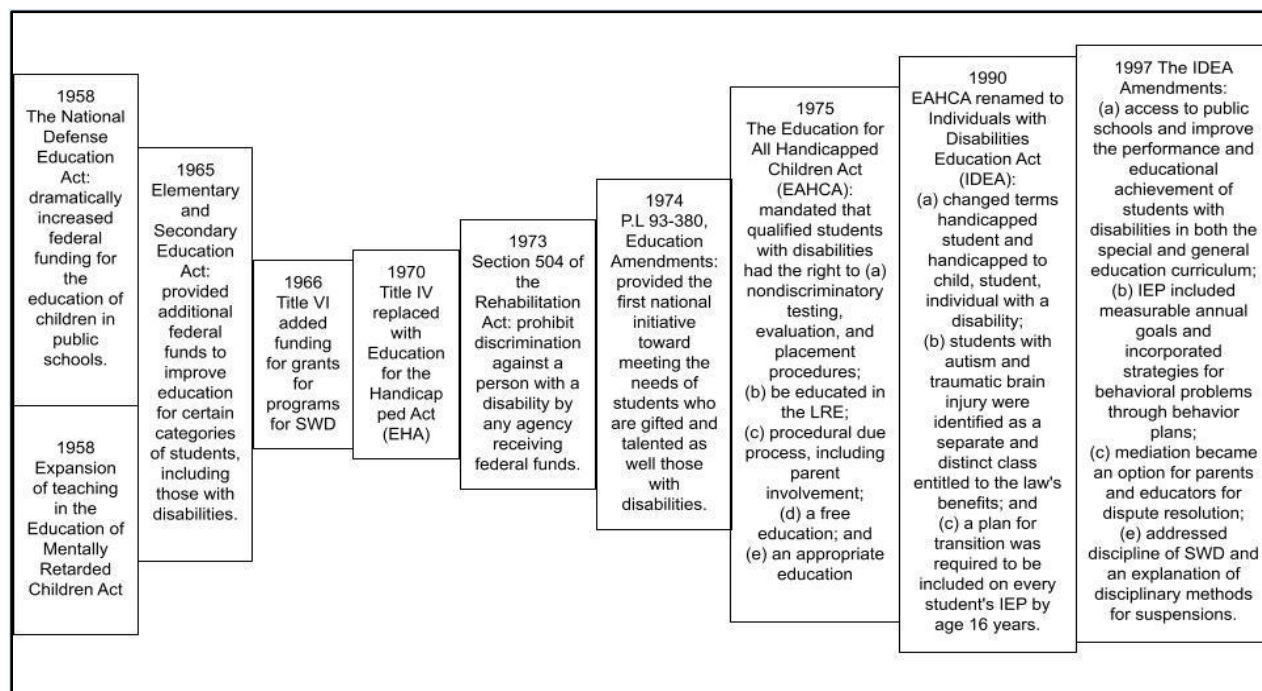
In 1975, President Gerald Ford signed into law the Education for All Handicapped Children Act (Public Law 94-142), which later became the Individuals with Disabilities Education Act (IDEA, 2004a). This law opened public school doors for millions of students with disabilities thus ensuring them an opportunity to make an impact on their communities (IDEA, 2004a). This law guaranteed the provisions of free appropriate public education (FAPE) in the least restrictive environment (LRE) for all children with a disability, from birth to 21 years of age, and their families, which are regarded as the foundation of modern special education. Additional amendments have led to greater access to the general education curriculum, provision services, transition services, and accountability for achievement (IDEA, 2004a). Prior to 1975, about 1.8 million children with disabilities were excluded from accessing education; IDEA now guarantees education to more than 7.5 million children with disabilities (Katsiyannis et al., 2001).

The laws regarding equal education for all children were made possible through the civil rights movement of the 1950-60s. The civil rights movement fought for the societal and the legal abolishment of racial segregation and discrimination in the U.S. The work done during this tumultuous period eventually served as the backbone for equality in education for people with disabilities (Yell et al., 1998). One of the landmark cases to come out of the movement, *Brown v. The Board of Education* (hereafter *Brown*,) stipulated protections under the law that if education is provided to one, then it must be provided to all citizens. The importance of education noted in the U.S. Constitution brought attention to racial segregation at schools being a violation of equal educational opportunities for minorities. Using the court's decision in *Brown*, advocates for SWD argued the tenants of equal education be deemed applicable to those denied an education due to a disability (Yell et al., 1998). Sixteen years after the *Brown*

decision, the concept of equal opportunity finally applied to SWD. The *Pennsylvania Association for Retarded Citizens v. Commonwealth of Pennsylvania (PARC)* became a landmark class action suit towards policies that excluded SWD. *PARC* argued four critical points in which states denied FAPE to SWD. The resolution specified that all children with mental retardation between ages 6 and 21 to be provided FAPE in programs like their nondisabled peers (Yell et al., 1998). These class action suits were the beginning of state laws which provide FAPE to SWD to receive a public education (Yell et al., 1998). Furthermore, legislative mandates were put into place to ratify and change laws to incorporate an equal educational opportunity for all students as seen in figure 1.

Figure 1

Legislative Mandates in Summary



Note. Information adapted from Yell et al., 1998.

Free Appropriate Public Education (FAPE) and Provision of Services

Through decades of class action suits and court case decisions fighting for equal rights for all students with disabilities, FAPE has become a cornerstone for special education law. Ensuring that students can read, write, and do basic arithmetic is no longer a sufficient end goal for public education (Vanbergeijk & Lengyel, 2021). Greater inclusion of SWD in the general education environment needs to occur to provide meaningful education and FAPE, for students to be successful members of society. FAPE means that special education and related services be provided at public expense, without charge to the families (Understanding Special Education, 2019). Such services meet the standards of the State and Local educational agency and include an appropriate education at all grade levels, provided in unison with the Individualized Education Program (IEP; IDEA, 2004e).

The case of *Andrew F. v. Douglas County School District* (2017; hereafter *Andrew*) raised the standard of evidence of FAPE and changed the expectation of provision of academic and related services listed in a student's IEP. The *Andrew* case focused on the idea that making "some" progress on academic and behavioral performance goals in an IEP was not a measurable standard in meeting FAPE and that the educational benefit for SWD needed to be more demanding (Vanbergeijk & Lengyel, 2021). From the results of the *Andrew* case, it is strongly advised that IEP teams assess educational needs individually, develop meaningful and measurable goals, rely on evidence-based practices and procedures, and make instructional decisions based on collected data (Vanbergeijk & Lengyel, 2021). An IEP must, therefore, be developed individually for each student in special education. This document contains the goals and objectives of the student's academic program, educational placement, the length of the

school year, and evaluation and measurement criteria developed in the IEP process (Yell et al., 1998).

The federal government has established a goal of providing full educational opportunities to all children with disabilities and a detailed timetable for accomplishing that goal. It has been clearly demonstrated, with more than 30 years of experience and research under IDEA, that the educational outcomes of SWD can be positively affected by establishing grand expectations and ensuring access to the mainstream education curriculum in their LRE placement, to the maximum extent possible (IDEA, 2004f). SWD are capable of meeting developmental goals within the IEP and meet the expectations established by the IEP team (U.S. Department of Education, 2019). The legal requirement under IDEA related to academic instruction is to prepare students to “lead productive and independent adult lives, to the maximum extent possible” (IDEA, 2004f). To meet this legal requirement, and to follow the *Endrew* case ruling, SWD must be provided with appropriate and available services that will enable them to reach positive academic and related outcomes.

Least Restrictive Environment (LRE)

An LRE is the placement of a student with a disability which promotes the greatest possible interaction with the generalized school population (Understanding Special Education, 2019). Removal of SWD from the generalized population should only occur when and if the nature or severity of the disability impedes academic gains and deemed unsatisfactorily within the generalized classes with the use of supplementary aids and services (IDEA, 2004e). LRE placement options, offered on a continuum, include “regular classroom with no support services, regular classroom with support services, designated instruction services, special day classes and private special education programs” (Understanding Special Education, 2019). LRE has the

interest of the students at the forefront of decision-making and is discussed and agreed upon by the IEP team members.

Individualized Education Program (IEP) for Students with Disabilities

The term individualized education program or IEP is a written statement for each child with a disability. This document is developed, reviewed, and revised annually by the IEP team members (IDEA, 2004e). Statements and descriptions of various areas, including academic achievement, are included in the IEP. Listed below are the eight legally required parts of an IEP in accordance with IDEA:

1. The student's current educational status
2. Measurable annual goals
3. A description of how the student's progress on annual goals is to be measured
4. A statement of the special education and related services and supplementary aids and services
5. An explanation of the extent to which the child will not participate with non-disabled children in the regular class or activities
6. The start date of services
7. Transition services
8. The instructional setting or placement

An IEP is required by law for students who qualify for special education services and a legally binding document held to exacting standards through the IDEA (International IEP, 2021).

Who are Students with Disabilities (SWD)?

Students With Disabilities (SWD) need special education and related services provided by FAPE. The term "students with disabilities" means a child diagnosed with "intellectual disabilities, deafness or hearing impairments, speech or language impairments, blindness or

visual impairments, serious emotional disturbance, orthopedic impairments, autism, traumatic brain injury, other health impairments, or specific learning disabilities” (IDEA, 2004f). Specific learning disability (SLD), speech or language impairments (SLI), other health impairments (OHI), and ASD make up 78% of all SWD categories (National Center for Education Statistics [NCES], 2021). Per IDEA, special education services that enable identified SWD to succeed in and out of school must be provided. The IEP document outlines the level of services and support needed on an individualized basis for each student. However, the type of services and support a student receives is also determined by their respective placement (or LRE) and where they spend their time throughout the school day.

Per the National Center for Education Statistics (NCES; 2021), the majority (95%) of SWD are enrolled in regular schools as opposed to specialized, separate schools. 65% SWD spend 80 percent or more of their time in general education classes, 18% of SWD spend between 40-79 percent of their time in general education settings, and 13% spend less than 40 percent of their time in general education settings. Students with speech or language impairments (88%), specific learning disabilities (73%), visual impairments (69%), other health impairments (68%), and developmental delays (67%) make up the largest portion of SWD who are inclusive with the general education setting (NCES, 2021). In contrast, 27% of students with ASD and 25% with intellectual disabilities make up the largest portion of SWD who are in specialized settings for the majority of their school day (Center for Public Education, 2021).

Background and Severity of Autism Spectrum Disorder (ASD)

ASD is known to be caused by biological, environmental, and/or both, factors (American Psychological Association [APA], 2013). “Researchers have suggested everything from environmental factors to processed foods to parents conceiving at more advanced ages”

(Wertheim & Apstein, 2016, p. 54). There have been autoantibodies found targeting brain proteins in both children with autism and their mothers (Goines & Van de Water, 2011). Specific environmental risk factors such as advanced parental age, birth weight, stressors and exposures to air pollution, heavy metals, and dietary contaminants may also contribute to the risk of ASD (APA, 2013; Herbert, 2010). Early signs of ASD include impaired communication, social interaction, and behavior. Successful treatment involves one or multiple social, behavioral, and/or educational interventions including behavior, positive reinforcement, and modeling as well as other evidence-based practices (Drayden-Edwards et al., 2021; NAC, 2009, 2011), and are reviewed in the next section.

ASD is defined by a broad range of characteristics which include difficulties with social skills, communication, and repetitive patterns of interests, activities, or behaviors (AutismSpeaks, 2022; Beckman et al, 2019; APA, 2013; Konukman et al., 2017; Nadeem et al., 2019). These difficulties tend to affect four general areas in speech, language, and communication; relating to people, objects, and events; responses to sensory stimuli; and developmental discrepancies in children with autism (Konukman et al., 2017). ASD is the fastest growing developmental disability in the country and is estimated to affect 1 in 59 children within the United States today and (AutismSpeaks, 2022; Wertheim & Apstein, 2016). Reported frequencies for ASD have approached 1% of the population and the reason for the increase remains unclear. ASD is a complicated disorder since there has yet to be any precise cause, methods for prevention or known cure (Kunzi, 2014; Wertheim & Apstein, 2016). The expanded definition and diagnostic criteria of ASD, differences in methodology, heightened awareness, increased state-financed support and early intervention programs, or a true increase in

the frequency of ASD have been identified as theories attributing to the fast growth of autism (APA, 2013; Wertheim & Apstein, 2016; Harris et al., 2019).

The severity levels of ASD are defined by APA in the *Diagnostic and Statistical Manual of Mental Disorders – Fifth Edition* (hereafter *DSM-V*; 2013). The *DSM-V* contains descriptions, symptoms, and other criteria for diagnosing mental disorders, provides a common language for clinicians to communicate about their patients, and establishes consistent and reliable diagnoses used in the research of mental disorders (APA, 2013). “It also provides a common language for researchers to study the criteria for potential future revisions and to aid in the development of medications and other interventions” (APA, 2013). The *DSM-V* encompasses three subtypes of autism spectrum disorder and posits “manifestations of the disorder also vary greatly depending on the severity of the autistic condition, developmental level, and chronological age: hence, the term *spectrum*” (APA, 2013, p. 53). The subtypes, level 3 “requiring very substantial support,” level 2 “requiring substantial support,” and level 1 “requiring support,” are used to drive this research in understanding the definitions and characteristics associated with the array of spectrum for ASD. It is important to note that ASD has been defined as a low-incidence and high-incidence over time which is due to the growing understanding of autism by both medical and school professionals. The next section will explain the different subtypes of autism and assist in understanding how students with autism are leveled into specific categories.

Severity Levels of Autism Spectrum Disorder

For the purposes of classifying students with ASD into levels to define the degree of developmental, social, and stereotypical mannerisms, this research considers students with ASD to be classified by level 3, level 2, and level 1 in accordance with the APA (2013). definitions

and common characteristics about each level are provided to understand the degree to which students are classified.

Level 3: Requiring Very Substantial Support

Level 3 characteristics of individuals with ASD include: “severe deficits in verbal and nonverbal social communication skills cause severe impairments in functioning, very limited initiation of social interactions, and minimal response to social overtures from others” (APA, 2013, p. 52). The restricted and repetitive behaviors of individuals with level 3 ASD consist of “Inflexibility of behavior, extreme difficulty coping with change, or other restricted/repetitive behaviors markedly interfere with functioning in all spheres. Great distress/difficulty changing focus or action” (APA, 2013, p. 52).

Level 2: Requiring Substantial Support

Level 2 characteristics of individuals with ASD include: “marked deficits in verbal and nonverbal social communication skills; social impairments apparent even with support in place; limited initiation of social interactions; and reduced or abnormal responses to social overtures from others” (APA, 2013, p. 52). The restricted and repetitive behaviors of individuals with level 2 ASD consist of “inflexibility of behavior, difficulty coping with change, or other restricted/repetitive behaviors that appear frequently enough to be obvious to the casual observer and interfere with functioning in a variety of contexts. Distress and/or difficulty changing focus or action” (APA, 2013, p. 52).

Level 1: Requiring Support

Level 1 characteristics of individuals with ASD stipulate that “without support in place, deficits in social communication cause noticeable impairments. Difficulty initiating social interactions, and clear examples of atypical or unsuccessful responses to social overtures from

others. May appear to have decreased interest in social interactions. ” The restricted and repetitive behaviors of individuals with level 1 ASD consist of “inflexibility of behavior causes significant interference with functioning in one or more contexts. Problems of organization and planning hamper independence” (APA, 2013, p. 52)

Importance of Levels of Autism

Based on their individualized level of severity and need in the academic setting, students in public schools who receive special education services through IDEA (2004) under the disability category of ASD, are provided instructional and related support. The three levels of autism as defined and described above are used to further categorize students in the study to identify differences in intervention effects by level of need. The importance of these definitions and facts about the severity levels of ASD is to give an understanding of the variety of characteristics that ASD encompasses, to understand the possible levels from mild to severe within ASD, and to show how characteristics overlap within each level. Autism is a spectrum disorder, and the spectrum is vast, from the intellectually limited to the merely socially awkward (Wertheim & Apstein, 2016). Wertheim and Apstein (2016) aptly described the spectrum in their statement, “as they say in the autism community, if you know one person who has autism, you know one person who has autism” (p. 54). The importance of the levels shows the spectrum of the disorder and that specific social skills, communication abilities, and behaviors move along that spectrum. The degree of severity of symptoms can vary among those with ASD, mostly affecting areas within personality and cognitive traits. For example, the increased ability to focus on details, the capacity to persevere in specific interests without being swayed by others' opinions, the ability to work independently, the recognition of patterns that may be missed by others, intensity, and an original way of thinking are all traits and characteristics within ASD

(Drayden-Edwards et al., 2021). Since level 3 is the least severe of the levels, some of the symptoms may be considered beneficial by many, and many people believe it has helped advance their professional lives (Drayden-Edwards et al., 2021). The three levels of autism will be considered when reviewing how EXM paired with an online resource is related to mathematical achievement.

Current Mathematical Performance for Students with Disabilities

Overall, students with disabilities perform far below same-aged peers without disabilities in mathematics (Gronna et al., 1998; Wei et al., 2012). Data from the National Assessment of Educational Progress (NAEP; 2019) shows the achievement gap between eighth-grade students with disabilities and those without disabilities has not improved in 16 years. In fact, students with disabilities score an average of forty points lower on mathematics achievement tests (NAEP, 2019). National mathematics achievement data is not available from disability groups currently. However, one can refer to state, county, and district data for further analysis into subgroup performance.

SWD whose LRE is mostly within the general education setting must participate in state testing designed for the general education curriculum (named the *Smarter Balanced Assessment or SBAC*); students may receive testing accommodations if listed in the IEP. Depending on the IEP team's decision, SWD, not receiving instruction within the general education curriculum, may be given an alternative assessment (California Alternative Assessment or CAA). Students' California SBAC testing data for the year 2020-2021 shows only 10.79% of all SWD met or exceeded the standard for math, meaning 89.21% of students did not meet the minimum standard for math. For students who took the CAA, 8.72% met the standard while 91.28% did not meet minimum standards in math (CDE, 2022).

In the same 2020-2021 year, only 4.92% of students with disabilities in San Joaquin County in California, met or exceeded the standard for math in the SBAC (as opposed to 95.08% of students who did not meet the standard). Similarly, only 1.01% of students who took the CAA met the minimum standard achievement level. Narrowing the focus even more, only 1.90% of students with disabilities within the Stockton Unified School District (SUSD) met or exceeded the standard for math in the year 2020-2021 in the SBAC (8.89 percentage points lower than the state average). Data for the CAA was only available for the 2018-2019 academic year as the district did not assess students during the COVID-19 distance learning year (2020-2021). In 2018-2019, only 4.73% of students who took the CAA met the minimum standard achievement level. Even though this data is from a previous year than others listed, it is still lower than the state average (by 3.99 percentage points) for the 2020-2021 academic year in which school closures and distance learning occurred. Interestingly, in the 2018-2019 school year, statewide data shows 9.54% of students who took the CAA met the minimum standard for math which is lower than the 2020-2021 data. Though these data could not be aggregated by disability type or setting in which the students are taught; students with ASD are included in the data.

The state government testing data site notes that care be used when interpreting test scores for the 2020-2021 year due to COVID-19's impact on teaching and learning during the 2020-2021 school year (CDE, 2022). Regardless of factors that contributed to the shockingly low math performance scores for students with disabilities, it is evident that significant support and use of effective practices in math instruction and learning are of immediate need to support the math achievement of students with disabilities, and particularly, students with ASD.

Effective Practices in Supporting Mathematical Achievement for Students with ASD

The outcome of mathematical achievement has a profound influence on student success in obtaining a high school diploma and working towards closing the achievement gap (Ma & Bradley, 2003; Pandey, 2017). Approximately 25% of students with ASD have a comorbid mathematics learning disability and struggle with these skills due to a variety of difficulties (Ledbetter-Cho et al., 2020). Mathematic achievement influences career options which may provide better opportunities for living a healthy lifestyle and being a productive member of society. Students with ASD in an SDC are far below their grade level in mathematical achievement thus being at a disadvantage in becoming successful in these areas (Root & Browder, 2017). Strategies such as persistent practice, schema-based instruction, and virtual manipulatives are proven methods of practice that can support math achievement for students with ASD. Below are brief descriptions of recent studies using these practices.

First, persistent practice could enhance the development of special skills, particularly in mathematical achievement (Peklari, 2019). For example, a developmental study of mathematics in children with ASD supports the notion of students with ASD being far below their typically developing peers. When 77 twelve-year-old children in the ASD group were compared to 43 twelve-year-old typically developing peers, the group mean-level showed lower achievement overall than typically developing peers (Bullen et al., 2020). However, the same group showed a comparable rate of growth in math computation over a 30-day period.

Second, a 2017 study focused on algebraic problem solving for middle school students with autism and intellectual disability rendered increases for all three participants (Root & Browder, 2017). The interventions used in this study were modified schema-based instruction (SBI) on steps of mathematical problem solving and time delay for vocabulary terms. SBI

teaches students the underlying mathematical structure of word problems (Jitendra et al., 2015). Participant one raised her scores from 4.4 points to 34.5 points. Participant two raised her score from 7.14 points to 31 points. Participant three raised her score from 2.75 points to 24 points (Root & Browder, 2017).

Third, the virtual manipulative intervention to teach subtraction with regrouping to students with ASD was used. This intervention allows students to use blocks and counters online to complete problems. Of the four participants, three were diagnosed with autism. Each participant showed improvement in this mathematical skill with a Tau-U effect size of 1.0 and maintained learned skills, suggesting the virtual manipulation intervention was highly effective (Park et al, 2020).

Effect of Exercise and Movement (EXM) on Students with ASD

Exercise and movement (EXM) are a critical area to study for (a) the potential argument of increasing physical education and/or other types of school-based EXM without risk of decreasing academic progress, and (b) offering a way to reduce disruptive behavior at school and drop-out rates from educational programs (Trudeau & Shephard, 2008). Whether or not academic success is related to EXM, findings have indicated that positive associations between the two exist among student populations (Fox et al 2010). Overall, students with ASD have lower sports participation rates than their typically developing peers and their peers with other disabilities such as emotional, developmental, physical and/or behavioral problems (Ryan et al., 2018). A better understanding of EXM is needed for this group of students, given that students with ASD decline in EXM as they get older, thus increasing the possibility of health risks as they get older (Ryan et al., 2018).

The second area to discuss is the importance of EXM in reducing disruptive behavioral occurrences and lowering drop-out rates. Beckman et al. (2019) explored self-monitoring (SM), a strategy consisting of planning, self-evaluation, monitoring, effort, reflection, and/or self-efficacy. Such skills have a positive correlation with youth's sports participation (Super et al., 2018). SM is a behavioral intervention commonly used for students with autism which focuses on improving the stereotyped or repetitive behaviors associated with ASD (Beckman et al., 2019, p. 226). Their study evaluated a self-monitoring application, goal setting, and reinforcement to improve on-task behavior and academic outcomes of two students with ASD. Results indicated improvements from baseline to intervention outcomes and improvements in academic performance seemed encouraging, particularly as they were implemented in a natural setting, with a classroom teacher serving as the intervention provider (Beckman et al., 2019). A different study focusing on the same intervention, self-monitoring, also showed positive results. The effectiveness of the self-monitoring intervention was demonstrated with two students across two academic subject areas. The students were taught skills in language arts and mathematics focusing on attending to tasks and academic accuracy. The researchers conclude that self-monitoring interventions resulted in positive changes in academic performance and on-task behavior: "Results are interpreted to conclude that the self-monitoring procedure was effective for both students and resulted in immediate increases in attending to task and academic accuracy even though results in academic accuracy were variable" (Holifield et al., 2010). Relatedly, Hansen et al. (1981) stated that using sports activity as a reinforcer was shown to have positive effects for academic response within the special education field. In their study, an eleven-year-old boy, given consequences (positive) to his on-task, in-seat behavior, results revealed that this

on-task behavior with positive reinforcement increased academic scores and assignment completion (Hansen et al., 1981).

Longitudinal studies demonstrate that academic performance was maintained or even enhanced by a student's physical activity (Shephard, 1997). In a survey done by a math teacher and football coach, results showed that general education participants in sports typically outperform their non-participant classmates in academics by being three times more likely to have a GPA of 3.0 or higher (Stagman, 2000). Stagman referred to other studies which range from athletics helping academic achievement to hindering academic achievement, but overall athletic participation does not hinder academic performance and it "instills desirable qualities such as physical fitness, goal setting, teamwork, and self-discipline that help in all areas of students' lives" (Stagman, 2000 p. 39).

EXM and Academic Achievement for Students with ASD

Students with ASD move differently than typically developing students (Green et al., 2008; Lynch & Gretchel, 2013; Ryan, 2018; Sarris, 2018; Stanish, 2017). There is a need to focus on coordination with students with ASD, yet exercise and movement, to aide academic achievement and decrease ASD characteristics, have not been implemented as an Evidence-Based Practice (EBP; defined in chapter 1) (Green et al., 2008; Lynch & Getchell, 2013). Only 14-20% of youths with ASD met the 2018 Physical Activity Guidelines for recommended daily minutes of moderate-to-vigorous movement; thus, being the lowest-performing sub-group (Pan et al., 2021). "Successful performance of goal-directed movements requires an integration of perceptual, cognitive, and motor processes," all of which are challenges for students with ASD (Lynch & Getchell, 2010). According to the results on the Henderson Test of Motor Impairment,

the Bruininks-Oseretsky Test of Motor Proficiency, and the Movement Assessment Battery for Children, 59-85% of students with ASD have movement problems (Green et al., 2008)

Additionally, physical movement has been associated with increased academic achievement in a variety of ways for all students, including students with ASD (Bittner et al., 2018; Ellemberg & St-Louis-Deschenes, 2010; Toscano et al., 2018). Teaching sports, games, and physical activities can be ways to improve vital social skills of children with autism (Konukman et al., 2017). However, children with ASD participate in activities less frequently than their typically developing peers, with less variety, therefore lessening opportunities associated with sports activities and decreasing their social abilities and health (Ryan et al., 2018; Stanish et al., 2017). There are a variety of possibilities as to why students with autism are less associated with EXM. Sarris (2018) stated motor skill deficits, safety concerns (half of the children diagnosed with ASD tend to run away), lack of understanding rules, and social communication as challenges impeding EM ability. Participation in EXM is essential for cognitive functioning, social communication, and motor and emotional maturation of children (Konukman et al., 2017). Overall, the association between students with ASD and EXM is that physical exercise not only improves the physical condition but also reduces the maladaptive behavioral patterns of people with ASD (Sowa & Meulenroek, 2012).

EXM as an EBP

There are a variety of evidence-based interventions that are useful for students with ASD (Yanardag et al., 2010). Evidence-based interventions come from research in applied behavior analysis (ABA) which primarily focuses on behavior and communication interventions (e. g., discrete trial training, functional communication training, and pivotal response training) and have been proven to be effective (Cooper et al., 2019). Interventions derived from behavioral models,

like ABA, including peer response training, self-monitoring/self-management, and priming techniques become useful for increasing learning and decreasing behaviors when working with students with autism who participate in sports (Cooper et al., 2019). Results from the Yanardag et al. (2010) study of exercise and sports for children with ASD indicate that using errorless teaching strategies, a component of ABA, all subjects maintained their play skills. These maintained play skills consisted of leg kicks while sitting on a pool deck, forward walking in the pool, a slow jog, paired kangaroo jumps, and throwing a ball into a ring. Additionally, they acknowledged that utilizing these practices in special education could provide a better opportunity for physical activity and sports for children with ASD (Yanardag et al., 2010).

Even though exercise can be used to improve performance with a task or behavior, or to increase physical fitness and motor skills, as previously stated, EXM is not a universally recognized EBP. Similarly, movement activities can include sports/recreation activities, martial arts, yoga, or other mindful practices that focus on specific sets of motor skills and techniques. EXM interventions can be performed in an individual or group/team-based settings and incorporate a warm-up/cool down and aerobic, strength, stretching, and/or skillful motor activities and. EXM is often used in conjunction with prompting, modeling, reinforcement, and visual support (Steinbrenner et al., 2020). For middle schoolers with ASD, technology-aided instruction and intervention (or TAI) can be used effectively to address communication, social, cognitive, school readiness, adaptive/self-help, challenging/interfering behaviors, and motor (Steinbrenner et al., 2020). More research is needed to strengthen EXM as an EBP for students with ASD, particularly when considering the current mathematical achievement of students with ASD, given that there are known positive effects of incorporating EXM into the learning environment, yet EXM is not considered a universal EBP for students with ASD,.

Technology-Aided Instruction and Intervention (TAII) and Students with ASD

TAII is an evidence-based practice endorsed by the council for exceptional children (CEC; AFIRM Team, 2020) and the National Professional Development Center on Autism Spectrum Disorder (Steinbrenner et al., 2020). TAII, for middle schoolers with ASD, can be used effectively to address communication, social, joint attention, cognitive, school readiness, academic/pre-academic, challenging/interfering behaviors, and mental health (Steinbrenner et al., 2020). TAII are those in which technology is the central feature of an intervention that supports the goal or outcome for the student (Steinbrenner et al., 2020). Technology has been defined as “any electronic item/equipment/application/or virtual network that is used intentionally to increase/maintain, and/or improve daily living, work/productivity, and recreation/leisure capabilities of adolescents with autism spectrum disorders” (Odom, 2013). TAII incorporates a broad range of devices, such as smartphones, tablets, and computer-assisted instructional programs. The common features of these interventions are the technology itself and instructional procedures for learning to use the technology or supporting its use in appropriate contexts (Odom, 2013). TAII meets evidence-based criteria with nine group designs and 11 single case design studies (Odom, 2013, AFIRM Team, 2020). According to evidence-based studies, this intervention has been effective for preschoolers (3-5 years) to young adults (19-22 years) with ASD (Odom, 2013).

Students with ASD tend to spend more time using technology than their typically developing peers thus having more sedentary time throughout their day (Pan et al., 2021). Technology can be a motivating factor for students with ASD since they are more comfortable communicating with inanimate objects (Goosen, 2019). Technology use in schools for students with ASD is heavily focused on communication and social skills (Odom et al., 2015; Tartaro et

al., 2015; Yee, 2012). Common uses of technology used to support students are computer-based instruction (McCoy et al., 2016), augmentative and alternative communication (AAC) devices (Crow et al., 2022), and promising newer technologies like virtual reality (Pandey, & Vaughn, 2021; Yakubova et al., 2021). While the integration of technology into the instruction of students with ASD can be a valuable and effective tool to increase skills and engagement, access to varying technologies is not necessarily attainable to every teacher. Students with an IEP may become eligible for technological support, depending on their individual needs but this does not mean all students with an IEP will receive their own devices (even if they would support instruction). However, because of budget constraints common to public schools, teachers and schools may not be able to provide each student with their own devices either; educators should make use of the technology they have available and utilize resources designed for students that are free or low-cost to the school.

Chapter Summary

This literature review discussed the background and severity of autism for those in an SDC setting, mathematical achievement of students with autism spectrum disorder (ASD) versus their typically developing peers, how movement is associated with higher academic achievement in mathematics, the use of technology for students with ASD, and why students with ASD tend to participate in movement less than their typically developing peers. The analyses of these topics were discussed to work towards closing the academic achievement gap for middle school students with autism in a specialized day class (SDC).

CHAPTER 3: METHODS

Quantitative Correlational Research Design

Effect of Exercise and Movement (EXM) offers knowledge and skills to promote mathematical achievement (Konukman et al., 2017; Yanardag et al., 2010). Studies have discussed how physical activity positively increases academic success for general education students and special education students in mainstream curriculum classrooms. For example, Castelli et al. (2007) found third and fifth-grade students who are physically fit are more likely to perform better on academic achievement tests. Additionally, more active students tend to perform better with academic achievement as shown through 11 out of 14 published studies from about 58,00 students between 1967-2006 (Troost, 2009). However, the correlation between physical activity and mathematical achievement for middle school students with autism spectrum disorder (ASD) who attend a special day class (SDC) for three years is unknown. According to CDE (2022), within San Joaquin County, 34.28% of general education students met or exceeded standard for mathematics in the 2020-2021 school year, while 10.49% of special education students met or exceeded the standard for mathematics. This clearly shows a gap between special education students meeting mathematical standards and a need to improve such skills to increase graduation rates.

To date, there has not been representation in EXM and academic achievement studies for students with ASD who attend an SDC for three years. Although promising, positive results for the inclusion of EXM into academic settings and performance have been explored, they have not been studied within populations of students who are showing high needs in math skill acquisition (Beckman et al., 2019; Holifield et al., 2010; Stagman, 2000). To address this concerning need, I

will employ an ex post facto (after the fact) correlational research study design using extant data (i.e., data that has already been collected) on student participation in GoNoodle's Mega Math Marathon as the intervention from a classroom setting with middle school students with ASD in an SDC.

Quantitative Correlational Research Questions

This study will attempt to answer the following questions:

1. Do the math fluency and calculation scores of middle school-aged students with ASD improve over time after engaging with the GoNoodle Mega Math Marathon intervention?
2. Is there a correlation between math fluency scores and level of ASD, days of exposure, time engaged, and variation of movement for students with ASD who interact with the GoNoodle Mega Math Marathon intervention?
3. Is there a correlation between math calculation scores and level of ASD, days of exposure, time engaged, and variation of movement for students with ASD who interact with the GoNoodle Mega Math Marathon intervention?
4. How do students with ASD respond to the GoNoodle Mega Math Marathon intervention as a tool to improve math skills?

For this study, the definition of EXM relates to the movement involved with GoNoodle (see figure 2 for examples and non-examples) and mathematical achievement measured by the extent to which the student has scored on their fluency and math calculation tests on the Woodcock Johnson-IV Tests of Achievement.

Figure 2*Examples and Non-Examples of EXM*

EXAMPLES	NONEXAMPLES
Jogging in place	Lifting weights
Walking in place	Running
Yoga	Swimming
Bending/Stretching	Playing a sport

This chapter will first explore the inquiry approach, methodology, and methods used in addressing the research questions. Then an explanation and description of the instrumentation used to measure the variables for this study will be followed by a description of the participants focusing on who they are, how they were selected, and a rationale for selection. Before addressing ethical considerations, threats to validity, and limitations of the study, the a review of data sources and analysis will be described.

Inquiry Approach

This study will investigate if a student's math achievement score improves after implanting the GoNoodle Mega Math Marathon intervention. This study will analyze teacher-collected pre-, mid-, and post- intervention data of 25 students with varying levels of severity in ASD before, during, and after implementation of the GoNoodle intervention. As the intervention and data collection took place outside this study's scope, this data will be analyzed extant (i.e., analyzing data after it has been collected). This study falls under the category of correlational research as group membership cannot be randomly assigned to extant data. Correlational

research is non-experimental in nature and allows the researcher to measure and determine the extent to which variables under investigation covary (Price et al., 2017). McMillan & Shumacker (2014) also define correlational research as “research in which information on at least two variables is collected for each subject in order to investigate the relationship between variables” (p. 2). Martella et al. (2013) identified three main characteristics to correlational research: hypothesis, grouping, and data. Below, I address how this study meets the correlational research characteristics.

- **Development of a hypothesis.** Hypotheses in correlational research design should be grounded on a theoretical framework and previous research. I hypothesized that students with ASD levels 2 and 3 would increase in their mathematical fluency and calculation skill achievement, more than students with ASD who are considered level 1. Additionally, I hypothesized that students with higher levels of participation, time, and movement in the GoNoodle intervention will have higher levels of improvement in their mathematical fluency and calculation skill achievement. This hypothesis was based on previous study findings that show incorporating movement in academics can improve student’s standardized test scores, on task behavior, and academic time on task, particularly when done consistently over time (Donnelly & Lambourne, 2011; Fedewa and Ahn, 2011; Kercood and Banda, 2012; Konukman et al., 2017; Shepard, 1997; Singh et al., 2012; Wold, 2019; Yanardag et al., 2010).
- **Selection of a homogenous group.** Group membership in a correlational study requires a definition of its members. A detailed description of participants for this study are defined in the section below but can be generalized into one homogenous group: students with

ASD who have moderate-to-severe support needs and receive the majority (over 50%) of their academic instruction in an SDC setting.

- **Collection and analysis of data.** Quantitative analysis lends itself well to correlational research. For this study, extant teacher-collected data will be the main source of data. I was the teacher of record during data collection. The intervention examined in this study was implemented as part of the school's emergency response to students' academic needs and was approved for use in this study after data was de-identified.

Purpose and Appropriateness

This study will attempt to identify a correlation between EXM and mathematical achievement for middle school-aged students with ASD in an SDC using GoNoodle's Mega Math Marathon. Quantitative analysis will be used within the correlational research framework to investigate the correlation between EXM and mathematical achievement in middle school students with ASD who attend an SDC for three years or more. Quantitative analysis is appropriate in investigating this need because it will provide an explicit description of data collection and analysis procedures through measurements and statistics using numerical data and deductive reasoning. With predicted results obtained, results may be replicated by others (McMillan & Schumacher, 2014).

Methodology

This study was conducted in a Title 1 public school serving students in pre-kindergarten through eighth grade. The school is located within an urban region of Northern California within the San Joaquin County - Stockton Unified School District (SUSD). As of February 2022, there were 792 students in the school, 266 of which were in grades six to eight. There are a total of 137 students attending the school served under IDEA and identified as having a disability.

Among these students, 90 have a primary diagnosis of ASD, with 25 being taught in an SDC sixth through eighth-grade classroom. Students who are between grades six and eight and have a primary diagnosis of ASD and taught in an SDC setting were the target population for this study. Participation in this study will benefit students by increasing EXM and increasing mathematics skills through means of a free online resource. This study will benefit the school by adding evidence-based approaches to the field of teaching for improved math skills and an alternative means to closing the gap between students with ASD and academic performance.

The study design structure is a pre-, mid-, and post-intervention design wherein baseline data are collected on student's math fluency and calculation achievement during the pre-phase of the study (i.e., before the intervention takes place), again in the middle of the intervention period, and once more during the post- phase of the study (i.e., after the intervention has concluded). Quantitative analysis will take place using descriptive analysis, a paired samples t-test, and a Pearson's product moment correlation test using the Statistical Package for the Social Sciences (SPSS) version 28 software once data is collected,. The study design and the data analysis methods were deemed appropriate as the study's aim was to improve mathematical skills through an online resource with students. The results of this study will inform practitioners about emerging evidence-based practices (EBPs) to incorporate EXM into their lesson planning for improved mathematical achievement for students with ASD.

Teacher-Researcher Role

I was not only the teacher of record who implemented the intervention but also the researcher that analyzed and interpreted the data. At the time of the study, I was employed as a special education teacher within the study site, teaching in an SDC with sixth to eighth-grade students who had a primary disability of ASD. By the start of the study, I had 9 years of

experience teaching in this environment and with students with varying levels of ASD. As an experienced educator of over 19 years of experience, I had a first-hand understanding and implementation of effective teaching practices specific to the setting and the students. However, in the current climate of special education (later discussed in chapter 5), I recognized the need for improved mathematical skills to address the gap between students on the spectrum and their ability to progress within the general education curriculum.

Because of disruptions in traditional learning environments caused by COVID-19 (i.e., daily, in-person school), students in my class faced significant impacts on their educational progress, particularly in math. The school leadership team and I decided to implement the intervention into the students' daily curriculum earlier than originally planned (i.e., during the 2022-2023 academic school year) as the need for intervention was immediate. Therefore, it was agreed that, with approval from the University of the Pacific and SUSD's Institutional Review Board (IRB) approval, data collected during this intervention period would be analyzed extant. The alternative option was to wait to implement the intervention in the 2022-2023 school year which would have been detrimental to students' educational progress. To ensure my role in the study was impartial and appropriate, I consulted with other researchers and the school-based academic and leadership team when establishing intervention procedures and data collection methods (described in the sections below). All data will be shared with the school's academic and leadership team, as this intervention was put into place to support the current needs of the students.

Instrumentation

To assess participants' pre-, mid-, and post- math achievement scores in the areas of fluency and calculation, three parallel versions of the Woodcock Johnson-IV tests of achievement were used. The intervention device, GoNoodle's Mega Math Marathon, will be used in this study. Descriptions of both instruments are below.

Woodcock Johnson-IV Tests of Achievement

The *Woodcock Johnson-IV Tests of Achievement* (hereafter referred to as *WJ-IV*) is the norm used in determining academic scores within SDC classrooms in SUSD. The *WJ-IV* is widely used to assess students with disabilities and ASD (Cain et al., 2019; Joseph et al., 2018; Macoun et al., 2020). This assessment is considered an appropriate tool to use to assess the current level of academic achievement in specified areas (Lockwood et al., 2021). The *WJ-IV* focuses on evaluation of relative strengths and weaknesses of the teste. It also helps assessment professionals identify and describe patterns of performance across achievement, language, and cognitive domains. These outcomes are a key factor in diagnosing learning problems and developing targeted interventions for individual needs (Schrank et al., 2014). The *WJ-IV* is an academic test given at any time and can be taken by anyone aged 2 to 90. This test allows the teacher-researcher to identify emergent cognitive ability and early academic skills to determine severity of delays, strengths, and weaknesses. Test times average about 5 minutes each and offered in paper-pencil format. The cost for a district to purchase this assessment can range between \$590 to \$1,449. The *WJ-IV* has three standard battery forms (Form A, Form B, and Form C). These three forms support assessment practices which are based on shared assessment and communication responsibilities among a team of professionals. Evaluators may alternate between Forms A and B for initial assessments and post-intervention testing. Form C is

designated for another professional to obtain additional evaluations. Use of the different forms by one or more examiners allows accurate comparison of evaluation results across time. This reduces dependency on a single form of the test and prevents potential over-exposure to items in any given form (Schrank et al., 2014).

Reliability and Validity of the *WJ-IV*. There are studies confirming that the *WJ-IV* produces valid and reliable results for test takers. The reliability of the *WJ-IV* scores, according to the *Mental Measures Yearbook (2017)*, were estimated with the split-half method and the test-retest method with a 1-day retest interval, and correlations were corrected for range restriction. The *WJ-IV* technical manual (McGrew et al., 2014) also provides detailed information on reliability coefficients for all tests, clusters, and composite scores for each age 2–19 and the seven adult age groups. The technical manual states:

“Median reliability coefficients were uniformly high: 38 of 39 were .80 or higher, and seventeen were .90 or higher. Test-retest correlations for speeded tests were mostly in the .80 to .90 range. Cluster scores include two or more tests and as such produce higher reliability estimates as predicted by true score theory” (p. 94)

The validity evidence of the *WJ-IV* is consistent with the *Standards for Educational and Psychological Testing* (American Educational Research Association [AERA], American Psychological Association [APA], & National Council on Measurement in Education [NCME], 1999, 2014). There is validity evidence related to the content, response processes, and relations with other variables which were determined to meet acceptable standards (Carney, & Wright, 2017). Validity evidence on the *WJ-IV* internal structure used exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) tests and cluster analysis. EFA and CFA results do not indicate a strong well-fitting model to the data across the two statistical programs which

challenges the merits of the test's internal structure (Carney, & Wright, 2017). Validity evidence on relations with other variables compared the *WJ-IV* to two different achievement batteries and a test of oral and written language found that the composite score correlations ranged between .60 to .70 within the separate academic areas, but some were in the .80 and .90 range (Carney, & Wright, 2017). Finally, tests of group differences were included in the *WJ-IV* validity evidence which included test takers with ASD, but the sample sizes are too small to definitively report results and are considered preliminary. The technical manual appendices provides full results of analyses.

GoNoodle

GoNoodle is an online movement and mindfulness website (Crabill, 2020). This tool incorporates movement with learning and provides educators with curricular integration with physical education. According to the GoNoodle frequently asked questions page, it helps teachers of kindergarten to fifth-grade students incorporate movement into learning. Students partake in short movement-focused activities that can be done next to their own desks in a classroom (GoNoodle, 2022a). The GoNoodle structure allows for students to walk, jog, sprint, in place while simultaneously answering math questions. The educator can choose the grade level for math questions, the answer mode to automatically reveal the answers or to manually choose the answers, and the play time for the activity length. GoNoodle encompasses four key features:

- **Research Based Activities.** Activities are based on research and science that help keep students healthy, active, and engaged.
- **Fast.** The set-up is simple and intuitive; activities can be as short as one minute.

- **Designed for Long-Term Engagement.** Activities are played as games that reward students and the more they participate, the quicker they level up.
- **Use for multiple classrooms by the same teacher.** Educators can track student progress in different classes through the rewards system and virtual mascot.

Specifically, the Mega Math Marathon game within the GoNoodle will be utilized for this study. Mega Math Marathon can be customized by the teacher to last between two and five minutes and questions within the game can range from eight to 20. There is a “sprint movement activity” in this game that can be between 1 to 6 sprints. For this game and in this study, “sprints” are defined as “jogging/running in place.”

Access and Cost of GoNoodle. GoNoodle is free to access and does not require any additional hardware or software. Teachers simply need a technology device with a screen and internet access to use GoNoodle. Additionally, the GoNoodle activities can be found on YouTube for educators who do not want to create an account (Tannir, 2021). For this study, I created an educator account and displayed the activity on the classroom’s large screen for all students to see and participate. Students can then engage with the game as a class, in a small group, or individually, following the prompts on the screen.

Reliability and Validity of GoNoodle. Though studies have been conducted on the effectiveness of GoNoodle on academic, behavioral, and physical achievement (Duke, 2018; Fedewa et al., 2018; Lotta, 2015; Ward, 2015; Whitney, 2016; Wold, 2019), little-to-no external information (i.e., not published by GoNoodle) can be found on the site’s overall reliability and validity. Of the existing studies, results provided evidence that aerobic-only movement breaks could support academic performance more than academic-based breaks. For example, Fedewa et al. (2018) conducted a study with 460 elementary school-aged students and found aerobic-only

brain breaks supported a greater academic achievement gain in math and reading outcomes as compared to aerobic brain breaks with academic content; the results were only statistically significant for reading. Whitney et al. (2017) found comparable results. In their study with 647 elementary school-aged participants, they found significantly greater reading scores over time and higher mathematics scores when using GoNoodle movement breaks versus the core-content based movement break group. Regardless of the results, it is important to highlight that EXM resulted in positive academic achievement for students in the treatment group using GoNoodle breaks (Fedewa et al., 2018). Both studies provide evidence that suggests physical activity breaks need to be appropriate for the student's cognitive abilities.

In reviewing dissertations and theses work conducted at institutes of higher education a focus on the use of GoNoodle was prominent. For example, Lotta (2015) used GoNoodle's Zumba activity breaks to explore its effect on academic achievement and student behavior in a diverse inclusive fourth-grade classroom with twenty-two students. After a 6-week span, playing GoNoodle Zumba for two to four minutes between lesson transitions, Lotta's findings indicated a slight increase in academic achievement and student behavior. Of the four students' detailed analysis, students' grades sometimes increased after the Zumba activity versus no activity for 50% of the data set. Additionally, students were less tired, had more stamina, and decreased off-task behavior. Ward (2015) was interested in understanding the impact of GoNoodle on off-task disruptions and behavior of third-grade students. During this research, ten third-grade students engaged with GoNoodle twice daily for six weeks. The study findings showed no significant difference between implementing Go Noodle to reduce off-task disruptions and behavior, $t(9) = -.05, p = .96$. Similarly, Duke (2018) used GoNoodle over a period of 18 weeks with sixth-grade students to investigate the impact of mathematics fluency, literacy fluency, and students'

attitudes toward school. Regarding mathematics fluency, the study data revealed GoNoodle was not statistically significant in improving test scores even though students scored higher on tests over time. Finally, Wold (2019) implemented GoNoodle as a physical activity to determine its effect on reading fluency by utilizing the DIBELS reading assessment to measure the findings. About 84,000 second and third-grade students in sixteen classes participated in the quasi-experimental, factorial design project. The researcher found “acute bouts of physical activity have a significant and positive effect on measures of accuracy and words retold” (Wold, 2019, pg. 20-21). Furthermore, peer-reviewed journal articles have also listed GoNoodle as a resource to introduce or increase physical activity and movement in the classroom (Rozalski et al., 2021; Swinth, 2015; Whitney, 2016) and specifically for students with ASD (Block et al., 2020).

There are white papers (i.e., an informational document or study conducted and reported by a company or private, non-peer reviewed organization) available on the GoNoodle website which supports the effectiveness of GoNoodle in improving students’ math skills. In 2014-2015, SEG Measurement conducted a study using Mega Math Marathon to explore whether students who used the program showed more mathematical skills improvement than similar students who did not use the program. Across fifteen schools and 3 states, 608 students and 27 teachers of third and fourth-grade classes participated. Conducting a quasi-experimental design, results were based on a comparison of pre and post-test results. Results of an ANCOVA test showed more growth in mathematical skills for those students in the Mega Math Marathon group than students who did not receive the intervention. From pre-test to post-test, the treatment group increased their scores by 50% indicating an improved performance of .16 standard deviations ($F = 6.638, p = 0.01$). A survey of teachers indicated that 100% reported positive student engagement with the program, 83% reported that the program was relevant to lessons and helped

improve math fluency for their students, and 93% reported the program made math more fun for their students. Students' responses to their survey reported 70% that the games helped them learn better and 73% reported that the games made learning more fun (GoNoodle, 2019a). Specific to Mega Math Marathon, GoNoodle cites a form of face validity (a subjective measure of how accurately an assessment measures the designated variable, just by looking at it) in their claim to have worked with core subject experts to develop the components within the game. Though face validity is subjective, it can be said that the site was created for students to increase movement related to their academic achievement in a variety of ways (i.e., games, activities, challenges).

SEG Measurement conducted another study during the 2017-2018 school year in areas of Texas with elementary students. Supported by Children's Health, 1,736 elementary schools have logged 180 million minutes of GoNoodle online activities. 726 teachers completed an online instrument about their use of and the effects of GoNoodle on their students and their teaching. Teachers reported the following positive effects: (a) improved students' memory, (b) improved overall academic performance, (c) improved student motivation, (d) improved students' attitudes toward school and schoolwork, (e) increased students' attention, focus and concentration, (f) improved students' in-class participation, (g) increased students' physical activity (GoNoodle, 2019b). Table 1 compares the findings from the previous peer-reviewed and non-peer-reviewed studies conducted on GoNoodle.

Table 1*Summary of Reviewed GoNoodle Research Findings*

Study Reference	ELA	Math	Behavior/ EXM	Student Perspective	Significance Result
Duke, C. (2018)	X	X	-	X	Not significant; students did score higher on tests over time.
Fedewa et al. (2018)	X	X	-	-	Significant for ELA
Lotta, B. (2015)	-	X	X	-	Significant
Ward, J. (2015)	-	-	X	-	Not significant
Whitney et al. (2017)	X	X	-	-	Significant
Wold, H. J. (2019)	X	-	X	-	Significant
SEG Measurement (2014-2015)	-	X	-	X	Significant
SEG Measurement (2017-2018)	-	-	X	X	Significant

Justification for Use of GoNoodle. It is important to note that without additional evidence from outside, peer-reviewed sources, GoNoodle has not shown to produce valid and reliable results in increased academic achievement, however, this resource remains an appropriate instrument for this study because of its convenience to the teacher-researcher, its

common core standards basis, and it was developed using research-based knowledge. As of January 2015, GoNoodle has two hundred million minutes of activity and is used in 49,000 schools by 274,000 teachers, and 5.5 million students (Ward, 2015). Because of its popularity, free access, and academic relevance, GoNoodle is an appropriate tool to use in this study.

After exploring the impacts that activities using GoNoodle have on academic achievement and student learning, I believed the GoNoodle Mega Math Marathon game could have a positive outcome for student learning and academic achievement in mathematics. Though the participants were in middle school (between sixth and eighth grade) at the time of this study, I used the GoNoodle activity that was academically and developmentally appropriate for the participants. Participants in this study were at least three grade levels behind their expected academic grade-level (for example, a sixth-grade student with ASD, who scored at a second-grade achievement level during the pre-test, would be included in the study), therefore the GoNoodle intervention was deemed appropriate to scaffold student learning. The activity planned for this study aimed at supporting student learning through increased physical activity and relevant curricular standards-based focus.

Tracking Exercise and Movement (EXM) in GoNoodle. An operational definition of the type of EXM students will engage in is needed, to collect data on students' engagement with GoNoodle related to the research questions. EXM in GoNoodle (for this study) is composed of two-levels. Level 1, *walking in place*, is defined as: standing next to a desk; feet and legs making small, short steps in place; knees movement ranges between 0-4 inches; arms moving slightly forward and backwards past hips). Level 2, *running in place*, is defined as: standing next to desk; feet and legs making large upward movement in place; knees movement range between 4-10 inches; arms bent, moving quickly forward and backwards at chest level). During

intervention sessions, participants were rated on a 4-point Likert scale with a score of 1 being ‘no participation’ (i.e., participants chose to not participate by staying seated at their desk); a score of 2 being walking in place only; 3 being running in place only; 4 being both walking and running in place during each segment of the intervention. This data determines the time of engagement and variation of movement the student participated in over the intervention.

Description of Participants

The target population was middle school students with ASD. To be included in this study, participants must have met the following criteria: (a) attend an SDC 50% of their day for more than three years, (b) able to communicate basic wants/needs verbally, (c) able to navigate technological devices such as i-Pads, laptops, computers, and smartphones, and (d) have a confirmed primary diagnosis of ASD. Twenty-five students at this site identified as potential participants for the study. All twenty-five were engaged in the pre-, mid-, post-testing and intervention during the 2021-2022 academic school year. Most participants in this study were 12 years old (n = 11), in seventh grade (n = 13), male (n = 22), of either Black or African American or White race (n = 12 total), of Hispanic/Latino ethnicity (n = 14) and required level 2 supports (n = 15). Table 2 shows a full breakdown of participant demographics.

Table 2*Participant Demographics*

Group	<i>n</i>	%
Age		
11	3	12
12	11	44
13	7	28
14	4	16
Grade		
6th	6	24
7th	13	52
8th	6	24
Gender		
Male	22	88
Female	3	12
Race		
White	6	24
Black or African American	6	24
2 or more races	2	8
American Indian or Alaska Native	1	4
Asian	5	20
Native Hawaiian or other Pacific Islander	1	4
Ethnicity		
Hispanic or Latino	14	56
Level of ASD		
1 - Requires support	4	16
2 - Requires substantial support	15	60
3 - Requires very substantial support	6	24

Data Sources

In this study, data was collected by the SDC classroom staff in the 2021-2022 academic school year as part of their regular operations. Data was analyzed extant because the need to provide math interventions and support to the students in the SDC setting was immediate. Data collection occurred outside of the scope of this study and external factors could not be controlled for (e. g., timeline for assessment and intervention, to be discussed in chapter 5). Data included in this study met the inclusionary criteria previously discussed and was de-identified prior to analysis by SUSD school leadership.

Intervention Procedures

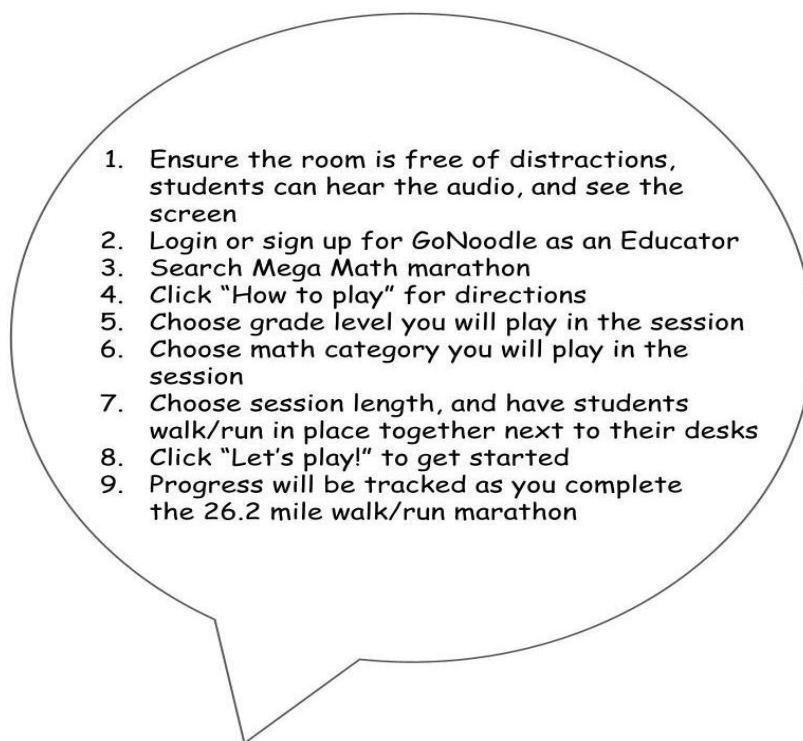
Although the original study was conducted outside this secondary analysis of data, I designed intervention procedures. This was possible through my unique role as teacher-researcher and as the school lead in implementing the intervention. After consulting with other researchers and the school leadership team, I followed the steps below when implementing the intervention and collecting accurate data.

1. Parent(s)/guardians were informed of the new intervention/activity introduced to their respective students per the school guidelines.
2. To understand student perspectives about physical activity engagement, an optional pre-social validity survey was provided to students. All twenty-five participants completed the pre-survey.
3. Before the intervention started the pre-test (version A of *WJ-IV* tests fluency and calculation skills) was administered.
4. Data collection trackers were created and classroom paraprofessionals (total of 5) were trained to use and track data. to ensure the data was tracked accurately and prior to starting the intervention, a practice round for data collection was conducted.
 - a. Data tracked included demographics, ASD level, days of exposure, time engaged, variation of movement, *WJ-IV* scores, and student perspectives.
5. During a 30-day period, the GoNoodle activity, with the whole class (about 10-14 students daily) was implemented.

6. I, along with the classroom paraprofessionals, monitored and tracked data daily when the intervention was in place for 5-minute increments (this is the maximum amount of time the GoNoodle Mega Math Marathon allows).
7. The *WJ-IV* Version B assessment was administered at the midpoint (i.e., after 10 days and 50 minutes total).
8. After midpoint testing, implementation of the GoNoodle activity, with the whole class (about 10-14 students daily) was conducted for the remaining time in the 30-day period following steps for data collection in previous steps.
9. At the end of the intervention period (i.e., after 30 days and 70 minutes total), I administered version C of the *WJ-IV* assessment.
10. To learn of their perspective on engaging in physical activity and if they benefited from participating in GoNoodle activities a follow-up optional post- social validity survey was provided to students.
11. Finally, all data was de-identified and analyzed.

Additionally, a 1-hour training in which I reviewed steps to implement the intervention, clarify definitions of observed movement and engagement, and practice taking data was held for the SDC teachers and paraprofessionals. Teachers and paraprofessionals were already moderately familiar with GoNoodle but were not familiar with taking observational data for brief time periods. There were two classrooms in which students received the intervention, classroom A and classroom B. Teachers and paraprofessionals, in both classrooms, were provided with simplified instructions which described the intervention procedures (see Figure 3).

Figure 3*Teacher-Created Intervention Procedures*

- 
1. Ensure the room is free of distractions, students can hear the audio, and see the screen
 2. Login or sign up for GoNoodle as an Educator
 3. Search Mega Math marathon
 4. Click "How to play" for directions
 5. Choose grade level you will play in the session
 6. Choose math category you will play in the session
 7. Choose session length, and have students walk/run in place together next to their desks
 8. Click "Let's play!" to get started
 9. Progress will be tracked as you complete the 26.2 mile walk/run marathon

Note: Information adapted from [GoNoodle \(2022b\)](#)

To implement the intervention of the GoNoodle Mega Math Marathon, each SDC teacher allotted a specified time for the intervention within the daily routine, 12:30 pm for Classroom A and 1:25 pm for Classroom B. The three staff in Classroom A and the three staff in Classroom B were given a student data sheet and informed on what to look for to track accurate data on student performance during each session (See appendix A). Each student data sheet had 2-4 names for staff to monitor during the five-minute session to minimize the number of students to watch at a given time. The SDC teacher then implemented the steps to begin the GoNoodle Mega Math Marathon session. While students were following the program (walking/running in place and calling out answers), staff were tracking data looking for movement patterns, and

listening to responses. After the session concluded, participants were given positive reinforcement through verbal praise and a token economy, which were already established practices in the classrooms. Classroom A was handed a chip to place in their class bowl to earn enough chips for a nacho party. Classroom B used quarter-shaped stamps to mark on a graph to earn a shopping trip. Participants in each classroom took a vote on their preference for a token economy. The intervention took place for twenty non-consecutive days within a 30-day period. It is important to note that positive reinforcement and token economies are considered an EBP for students with ASD and typically used as part of the SDC setting (Neitzel, 2009). The addition of the reinforcer (nacho party or shopping trip) was not solely used for this intervention and was not a stipulation to the class's ability to receive their preferred incentives.

Data Analysis

To begin and defined below, explanations of the operational definitions of the four independent variables are included in this study:

- **Level of ASD.** The first independent variable was determined by the student's placement in the SDC and confirmed by the teacher of record. Chapter 2 offers the full descriptions of the levels of ASD.
- **Days of Exposure.** The second independent variable was determined by the number of days students were present in the classroom while the intervention was in-use. This variable did not account for students engaging in the intervention, just their exposure to the tool.
- **Time Engaged.** The third independent variable was determined by the amount of time in minutes students actively engaged in the intervention. A student earned from 0-100 minutes of time engaged for the entire intervention. Actively engaged referred to having

a movement score of 2, 3, or 4 in which the students received a five in units of minutes for each session. A score of 1 or if the student was absent received a zero in units of minutes. See Appendix A for score meanings.

- **Variation of Movement.** The fourth independent variable was determined by averaged movement scores. Average scores, a total count of scores 1, 2, 3, and 4, were added together and then divided by the number of sessions. The number of sessions was equivalent to the days of exposure. This allowed me to see if students were mostly incorporating a type of motion while participating in the intervention or no motion during the intervention.

The dependent variable, mathematical achievement, was measured by how much the participant scored on their fluency and math calculation tests of the *WJ-IV*. Test five in the *WJ-IV* was used for math calculation and test 10 was used for math fluency. Form A of each *WJ-IV* test was used for the pre-test; form B of each test in the *WJ-IV* was used for the mid-test; and form C of each test in the *WJ-IV* was used for the post-test. Prior to delivering the intervention, participants completed the *WJ-IV* pre-tests. The mid-tests were administered after 10 sessions of the GoNoodle Mega Math Marathon intervention. The post-tests were administered after the participant completed 20 sessions. A maximum of 20 data points were collected for each participant including absences. Improvement of scores was assessed according to the outcome of the three *WJ-IV* tests of achievement forms.

To answer research question one, I first utilized a paired-sample t-test to measure the outcome of *WJ-IV* scores to determine whether there are any statistically significant differences between the means of participants' *WJ-IV* math fluency and calculation scores from pre- to mid-test, mid- to post-test, and pre- to post-test. This is appropriate when the goal is to determine if

there is a significant mean difference in student performance on fluency and calculation over time. I had to calculate a difference score between each testing time point before interpreting the test results. When interpreting results, I assessed the statistical significance value (p -value) which is the probability that the participants' *WJ-IV* scores will be statistically different from the assumed scores. If $p < .05$, this meant that the mean difference between the two time periods (e. g., pre- to mid-test) was statistically significant. Alternatively, if $p > .05$, this meant I did not have a statistically significant mean difference between two time periods.

To answer research questions two and three, I conducted Pearson's Product-Moment Correlation test only for the remaining variables which proved significant in the paired samples t -test. The main reason to conduct this analysis was to obtain the Pearson's Correlation coefficient value, r , which informed whether the variables were linearly related. The coefficient also informed the direction and magnitude between linearly related variables (Laerd, 2018). A positive coefficient would indicate a positive correlation between the variables. Alternatively, a negative coefficient indicated a negative correlation between variables. Magnitude, or strength of the correlation, was determined using Cohen's (1988) guidelines where values of 0.1-0.3 indicated a small correlation, 0.3-0.5 indicated a medium or moderate correlation, and values $>.05$ indicated a large or strong correlation. The p -value was used to assess if the linear relationship between the variables was statistically significant. If $p < .05$ I determined there was a statistically significant linear relationship between variables. This was deemed an appropriate test as the goal was to determine whether there was a correlation between the mean difference score and students' mathematics achievement scores on the *WJ-IV*. SPSS version 28 computed all quantitative data analysis.

Finally, to answer research question four, I utilized descriptive statistics to analyze how participants reported their perceptions of the use of GoNoodle to ascertain whether student perceptions of the tool impacted math fluency and calculation achievement. Analysis of participant responses is a form of social validity and results informed if the perception of students with ASD correlates with math fluency and calculation scores. Perceptions of such a tool are a crucial factor to consider when implementing and continuing the use of any resource as it can increase engagement and prolonged use of the tool. Figure 4 displays the social validity survey questions for participants. The social validity survey was constructed on Google Forms and a copy of questions asked of participants for the post-assessment can be seen in Appendix B. Appendix C provides a copy of the Google Forms pre-assessment questions asked of participants.

Figure 4

Social Validity Survey Questions

Pre-Intervention	Post-Intervention
<ol style="list-style-type: none"> 1. Do you enjoy physical activity? 2. Do you enjoy math? 3. Do you enjoy movement breaks in the classroom? 4. What, if any, physical activities do you participate in outside of school? 	<ol style="list-style-type: none"> 1. GoNoodle Mega Math Marathon is fun. 2. Do you enjoy physical activity? 3. I felt healthy playing GoNoodle Mega Math Marathon. 4. I learned more math skills by playing GoNoodle Mega Math Marathon. 5. I enjoyed playing GoNoodle Mega Math Marathon. 6. GoNoodle Mega Math Marathon was exciting and enjoyable. 7. I would like to do more activities with GoNoodle. 8. Do you enjoy math? 9. Do you enjoy movement breaks in the classroom?

Ethical Considerations

In this correlational research study quantitative measures were used and participants were given opportunities to have equal amounts of time to participate. All the names from the surveys are confidential and are not needed for the purpose of this study. Participants' identities were de-identified and names replaced with arbitrary codes. Access to the student surveys and the data collection tools were accessed from a computer at the school site or at home. The online data collection files were saved on the university's secure cloud space (OneDrive) in a password-protected file, only accessible to myself and my dissertation supervisor. Data was de-identified. To assist with minimizing any potential harmful effects, approval from the SUSD research and accountability department and IRB approval from the University of the Pacific were obtained.

Threats to Validity

The internal validity relates to the extent to which one feels confident about confounding and extraneous variables being controlled (McMillan & Schumacher, 2014). Threats to internal validity may have consisted of the maturation of the subjects. Maturation refers to the age and physical growth of participants over the intervention. Though the intervention period was relatively short (30-day period), participants in the study underwent physical and hormonal changes common to the age group (Cleveland Clinic, 2021) or environmental changes known to affect individuals with ASD (Konukman et al., 2017) that may have impacted their overall participation and engagement levels in this study, these factors cannot be controlled for. Any positive results in academic growth could also be due to confounding variables like the participants being of middle school age (between 11-14 years old) and therefore have more experience and exposure to academic material and physical activity opportunities.

The threat to the selection of participants may have also been a concern for this study. Participants ranged between various levels of autism which may have affected their outcomes in mathematical achievements and physical ability. Students at ‘higher levels’ of ASD may have been more sensitive to environmental and physical factors which require more support, and vice versa. However, within SUSD, students are placed in the SDC setting based on need and not specifically on the level of ASD, meaning the participants in this study spanned all three levels.

Assumptions and Limitations of the Study

Evaluators of this study who are not familiar with disabilities which affect learning, special education, and ASD may view positive results from this study as a one-size-fits-all approach to increasing mathematical fluency in calculation for all students with ASD. I conducted this study with the assumption that positive results are indicators of evidence-based informed practices that are suited to the participants in the study. Any generalizable information that adds to the EBP literature base derived from the results of this will need further testing to determine if the intervention is appropriate for larger groups of students with ASD. Additionally, it is fair to assume that the researcher followed protocol on the *WJ-IV* tests and effectively trained other staff on data collection. The chosen study design also yielded five major limitations to be considered before evaluating the data, listed below:

- **Social validity survey.** The social validity survey may have its limitations since it is a self-reported recollection of their engagement in the activity. Since all the students in the study had previous exposure to GoNoodle, their perspectives on its effectiveness for increasing EXM engagement and math skills may not have been accurately expressed but are nonetheless important for establishing social validity.

- **Generalizability of the data.** The ability to generalize findings was impacted as this study was limited to one middle school's SDC population. As a result, the demographics of the participants may not be representative of other classes, districts, or national groups.
- **Confounding variables.** Confounding variables not accounted for in this study have the potential to affect the results. For example, the number of staff assisting in data collection, other curriculum being taught simultaneously, and the timeframe for the study being shortened due to the immediate need for intervention, could not be controlled for. Ideally, this study would be conducted over a full academic semester or longer period.
- **GoNoodle.** Within this study, the elements could not be controlled, within the GoNoodle tool. The website's music options, selection of math concepts, background image options were limiting and could be jarring or unpleasant for students in the study with sensory needs.
- **Students as participants in the study.** There are student-level factors that could be limitations to the rigor of this study and data collected. For example, individual attendance, the time of day for the activity, and daily mood/motivation to participate, could have played a role in overall engagement and performance.

Chapter Summary

For this correlational research study, I will investigate the correlation between EXM and mathematical achievement through use of an online resource, GoNoodle. The data will be analyzed and obtained from *WJ-IV* scores for fluency and calculation skills and from the social validity survey. Results could yield useful information about EXM and its effect on mathematical achievement to meet this legal requirement in providing SWD appropriate and available services enabling individuals to reach positive academic and related outcomes.

CHAPTER 4: FINDINGS

Outcomes and Analysis of Research

The purpose of this quantitative correlational study sought to assess if the use of GoNoodle's Mega Math Marathon, an online interactive tool, as a mathematics intervention for middle-school aged students with autism spectrum disorder (ASD) resulted in improved fluency and calculation skills as an attempt to lessen the educational gap between grade-level and academic achievement for students with ASD. Results were determined by differences in pre-, mid-, and post- Woodcock Johnson IV (*WJ-IV*) scores. Specifically, this study aimed to identify if relations exist between fluency and calculation scores and (a) level of ASD, (b) days of exposure, (c) time engaged, and (d) variation of movement. I hypothesized that students with higher levels of involvement in the GoNoodle program would significantly improve students' mathematical fluency skill and calculation achievement. Data were collected over a 30-day period consisting of 20 sessions using the GoNoodle Mega Math Marathon intervention which took place during normal school operations.

Descriptive analyses, paired samples t-tests, and Pearson's product-moment correlation tests were conducted to answer the study research questions which aimed to ascertain the effects of GoNoodle's tool on students with ASD. Additionally, students who participated in the study were given a social validity survey before the intervention was put into place and after the study was completed to answer research question 4 (see all research questions below). These surveys were designed to gauge the perceptions of student-users of the online tool and add social validity evidence to the study. The information was entered into the Statistical Package for the Social Sciences (SPSS) for statistical analysis.

Descriptive Analysis Results

Descriptive analyses included total counts, or frequencies of demographic variables related to the participants (i.e., level of ASD, gender, age, race, and ethnicity). This analysis determined if the participants could be compared on demographic factors known to influence academic achievement (Blandon, 2018). Review of the frequency of demographic factors for the participant population is an important first step in any research seeking to deduce generalizable results for an intended population (Hammer, 2011). The interpretation of this data could be misconstrued if generalized to an entire population since the participants were not evenly represented in the sample.

The primary demographic variable of importance for the descriptive analysis was the level of ASD. The frequency tests showed the level of ASD among study participants was very skewed; there were four students classified as level one, fifteen students classified as level two, and six students classified as level three as seen in Table 3. Because the numbers of students in each ASD classification level were uneven, I could not make fair or accurate comparisons of student math achievement performance on this factor, therefore I excluded it from analysis of research questions two and three.

Table 3*ASD Classification*

ASD	Gender (n)	Age (n)	Race (n)	Ethnicity (n)
Level 1	Male (4)	12 (2)	White (1)	Hispanic (1)
		13 (1)	Black or African American (1) Native Hawaiian or Other Pacific Islander (1)	Not Hispanic (3)
		14 (1)	Islander (1)	
Level 2	Male (13)	11 (2)	White (3)	Hispanic (10)
	Female (2)	12 (8)	Black or African American (3)	Not Hispanic (5)
		13 (2)	American Indian or Alaska Native (1)	
		14 (3)	Asian (5) Unknown (4)	
Level 3	Male (5)	11 (1)	White (2)	Hispanic (3)
	Female (1)	12 (1)	Black or African American (2)	Not Hispanic (3)
		13 (4)	2 or more races (2)	

Paired Samples T-Test

After demographic analysis, I proceeded to assess the dependent variable, *WJ-IV* scores, to answer research question 1: *Do the math fluency and calculation scores of middle school-aged students with ASD improve over time after engaging with the GoNoodle Mega Math Marathon intervention?* It is important to note that terminology in data interpretation differs when reporting paired samples t-tests results. Martella et al. (2013) inform that although a paired samples t-test can analyze differences between variables and time points, when dealing with time, one should use the term ‘change’ to discuss observed changes over time points (ex: changes in academic performance over pre- and mid- time points). Likewise, when dealing with variables which are

not related to time, one should use the term ‘differences’ to indicate observed differences across variables (Laerd, 2022).

To answer research question one, I first calculated the change in scores between participants’ *WJ-IV* assessment scores for fluency and calculation from pre- to mid-test, mid- to post-test, and pre- to post-test to understand if there were changes in student performance throughout all three time periods. To do this, I used the Transform function in SPSS to compute a new variable which became the change in score between test scores at different time points. For example, to find the difference score between the pre- and mid-fluency test, I subtracted the latter from the former and the change score was then recorded as a new variable. This calculation was computed three times for each time period between fluency scores and three times for calculation scores, for a total of six times. See example of score difference calculation in Figure 5 below.

Figure 5

Obtaining a Difference Score

$$\begin{array}{ccc} & \text{Difference} & \\ & \text{Scores} & \\ \text{WJ-IV Mid-test} & - & \text{WJ-IV Pre-test} \\ & = & \\ & \text{New Variable} & \\ & \text{(i.e., } \textit{diff_p2m_FL} \text{)} & \end{array}$$

Tests for Assumptions: Outliers

The next step in the paired samples t-test procedure was to conduct tests for assumptions. Ensuring the data meets the assumptions required to accurately interpret results is a critical step in conducting a paired samples t-test (Ghasemi & Zahedias, 2012). The tests for assumption conducted in this stage of analysis were used to determine if the data had significant outliers and were normally distributed. First, to assess if significant outliers were present in the data, I used the Explore function in SPSS to create boxplots for each change score as previously stated (see Appendix D Figures D1-D6). Next, I visually assessed the boxplots to determine if outliers existed and if they were significant enough to warrant removal from the dataset. SPSS denotes 'regular' outliers that are more than 1.5 box lengths away from the edge of the box with circular dots and 'extreme' outliers that are more than three box lengths away with asterisks. The thirteen outliers were found across the six box plots; all the fluency change scores indicated outliers were present and one of the calculation change scores had outliers present in the data. Of the thirteen identified, ten were more than 1.5 box-lengths from the edge of the box in a boxplot. The inspection of their values did not reveal them to be extreme and they were kept in the analysis. I decided to retain these regular outliers because they did not unduly influence the change scores or the conclusion of the paired samples t-test.

Table 4*Overview of Outliers*

Variable	Variable Name	Outliers in SPSS
Pre-mid fluency	Diff_p2m_fl	8*, 11 ^o , 17 ^o
Pre-mid calculation	Diff_p2m_calc	-
Pre-post fluency	Diff_p2p_fl	8*, 11*, 1 ^o , 17 ^o
Pre-post calculation	Diff_p2p_calc	-
Mid-post fluency	Diff_m2p_fl	22 ^o , 1 ^o
Mid-post calculation	Diff_m2p_calc	9 ^o , 19 ^o , 15 ^o , 13 ^o

Note. * = extreme outlier; ^o = regular outlier. Numbers listed in the ‘Outlier in SPSS’ column refer to their positional case number on SPSS.

According to the SPSS standards and visual inspection, the remaining three outliers were considered extreme; they came from two different participants (student 8 and student 11 in SPSS). When the extreme outliers are not caused by data entry or measurement errors, they are described as “genuinely unusual” data points (Laerd, 2022; Wu & Vos, 2018). Although these unusual data points are not ideal for statistical analysis, they can be analyzed further through a Wilcoxon signed-rank test.

Wilcoxon Signed-Rank Test. The Wilcoxon signed-rank test is used to determine whether there is a median difference between the paired or matched observations. The Wilcoxon test is designed to compare two continuous paired groups to determine if two or more sets of pairs differ from one another in a statistically significant way (Hayes, 2021). This test can be considered as the nonparametric (i.e., test that does not assume data is normally distributed; IBM, 2022) equivalent to the paired-samples t-test and can be used to determine differences over

time between related groups. Like all other statistical tests, the assumptions for the Wilcoxon Signed-Rank Test needed to be met prior to conducting the test. First, I ensured that the dependent variable (*WJ-IV* pre-, mid-, and post-tests) was measured on a continuous level and the independent variable (days of exposure, time engaged, variation of movement) consisted of related groups. Using the Related Variables function in SPSS, I input the change score variables and the independent variables for fluency scores.

Results from the pre-mid fluency test indicated a p -value of 0.217 which is greater than .05 meaning there was not a statistically significant result and there was no median difference between the related groups in the population (i.e., the median difference is not statistically significantly different from 0). Visual inspection of the histogram produced in this test showed, of the twenty-five participants recruited to the study, the GoNoodle Mega Math Marathon intervention elicited an improvement in mid-test fluency scores in 13 participants compared to the pre-test fluency scores whereas two participants saw no improvement and 10 participants did not elicit improvement.

Results from the pre-post fluency test indicated a p -value of 0.180 which is greater than .05 meaning there was not a statistically significant result and there was no median difference between the related groups in the population. Visual inspection of the histogram produced in this test showed, of the twenty-five participants recruited to the study, the GoNoodle Mega Math Marathon intervention elicited an improvement in post-test fluency scores in 17 participants compared to the pre-test fluency scores whereas four participants saw no improvement and seven participants did not elicit improvement.

Results from the mid-post fluency test indicated a p -value of 0.139 which is greater than .05 meaning there was not a statistically significant result and there was no median

difference between the related groups in the population. Visual inspection of the histogram produced in this test showed, of the twenty-five participants recruited to the study, the GoNoodle Mega Math Marathon intervention elicited an improvement in post-test fluency scores in seven participants compared to the mid-test fluency scores whereas three participants saw no improvement and 15 participants did not elicit improvement. Table 5 provides a summary of the Wilcoxon Signed-Rank Test Hypothesis; All histograms produced by the Wilcoxon tests can be seen in Appendix D, figures D1-D6.

Overall, the p -value was greater than .05 (i.e., $p > .05$) for all paired groups in the fluency change scores. Therefore, there was not enough evidence to declare the median difference was statistically significantly different from zero. Moving forward, since they were not statistically significant, all fluency variables were removed from any further analysis,.

Table 5

Wilcoxon Signed Rank Test Hypothesis Summary

Null Hypothesis	Test	Sig.	Decision
The medium of difference between Pre-Fluency and Mid-Fluency equals 0	Related-Samples Wilcoxon Signed Rank Test	0.217	Retain the null hypothesis.
The medium of difference between Pre-Fluency and Post-Fluency equals 0	Related-Samples Wilcoxon Signed Rank Test	0.18	Retain the null hypothesis.
The medium of difference between Mid-Fluency and Post-Fluency equals 0	Related-Samples Wilcoxon Signed Rank Test	0.139	Retain the null hypothesis.

Note. The significance (p -value) is set at .050.

Tests for Assumptions: Normality

The second assumption test of normality was assessed, primarily, by the Shapiro-Wilk test. The Shapiro-Wilk test assesses the data that is normally distributed and is recommended for data with small sample sizes (King & Eckersley, 2019). The Shapiro-Wilk test produces Q-Q Plots can be used to assess the distribution of data, but this method is best utilized with a large sample size (> 50 participants; King & Eckersley, 2019), thus, I used the Shapiro-Wilk test results. Results that indicate the significance value to be greater than .05 (i.e., $p > .05$) were determined to be normally distributed. Results with significant values less than .05 (i.e., $p < .05$) violated the assumption of normality. The significance values for all three calculation scores (pre-mid, pre-post, and mid-post) were greater than .05 ($p = .091, .233, .219$, respectively). The assumption of the normality was not violated for all calculation scores retained from the previous step, as assessed by Shapiro-Wilk's test (see Table 6).

Table 6

Shapiro-Wilk Test Results for Calculation Scores

	Statistic	<i>df</i>	Sig.
Pre-mid	0.931	24	0.091*
Pre-post	0.865	24	0.233
Mid-post	0.969	24	0.219

Note. *df* refers to degrees of freedom. The asterisk (*) refers to values meeting the sig., or significance (i.e., *p*-value), threshold set at <0.05.

Paired Samples T-Test Final Results

After completing the tests for assumptions, I analyzed the results of the paired samples t-test to determine whether there was a statistically significant mean difference between the *WJ-IV* assessment scores from pre-mid, mid-post, and pre-post data on calculation scores only.

Participants showed an increase in mathematical calculation achievement from the pre-test ($M = 63.44$, $SD = 10.79$) to the mid-test ($M = 67.24$, $SD = 13.31$). Participants also showed an increase in mathematical calculation achievement from the pre-test ($M = 63.44$, $SD = 10.79$) to the post-test ($M = 68.44$, $SD = 12.19$). However, participants showed a decrease in mathematical calculation achievement from the mid-test ($M = 67.24$, $SD = 13.31$) to the post-test ($M = 68.44$, $SD = 12.19$).

Participants elicited a mean increase of 3.800, 95% CI [.442, 7.158] from pre-test to mid-test timeframes, the difference in scores was statistically significant, $t(24) = -2.336$, $p = .028$. Similarly, participants elicited a mean increase of 5.000, 95% CI [2.218, 7.782] from pre-test to post-test timeframes and the difference in scores was statistically significant, $t(24) = -3.71$, $p < .001$. Conversely, participants elicited a slight mean increase of 1.200, 95% CI [-4.179, 1.779] from mid-test to post-test timeframes, but the difference in scores was not statistically significant, $t(24) = -.831$, $p = .414$.

The effect size was calculated for the pre-mid and the pre-post t-test results. Reporting effect size clarifies the magnitude of differences found in the results and adds credibility to the interpretation of the p value (Sullivan & Feinn, 2012). The Cohen's d effect size is an appropriate measure for the t-test results (Laerd, 2018). To calculate Cohen's d effect size, I divided the mean (M) by the standard deviation (SD). Then, using Cohen (1998) recommendations for interpreting the strength of the effect size (0.2 = small effect, 0.5 = medium

effect, and $0.8 =$ large effect), I found $d = .467$ (medium effect) for the pre-mid scores and $d = .742$ (large effect) for the pre-post score significant (Laerd, 2018). Since mid-post tests results were not significant, the effect size was not calculated and calculation skills for this timeframe will not be evaluated in further analysis.

Since all the fluency scores and the mid-post calculation scores were not found to have a linear relationship or a normal distribution of data, I did not conduct further tests to determine if a correlation between *WJ-IV* scores and other independent variables existed. This determined that I could not answer research question two: *Is there a correlation between math fluency scores and level of ASD, days of exposure, time engaged, and variation of movement for students with ASD who interact with the GoNoodle Mega Math Marathon intervention?*

Pearson's Product-Moment Correlation

Following the paired samples t-test, I proceeded to assess the independent variables, (a) days of exposure, (b) time engaged, and (c) variation of movement. Since previous descriptive analysis showed an unequal grouping of students in different ASD levels, I did not test for this variable on research question three, *Is there a correlation between math calculation scores and level of ASD, days of exposure, time engaged, and variation of movement for students with ASD who interact with the GoNoodle Mega Math Marathon intervention?* Doing so would have resulted in skewed results.

The Pearson's product-moment correlation coefficient test (hereafter: Pearson's) is used to measure the strength and the direction of a linear association between two variables; this test produces a Pearson correlation coefficient, denoted by r (Laerd, 2018). A Pearson's test attempts to draw a line of best fit through the data of the two variables and the coefficient r indicates how changes in one variable correspond to changes in another variable (Chao, 2017).

Pearson's is an appropriate test following paired samples t-test because it will determine if the remaining dependent variables (i.e., change in WJ-4 calculation scores between pre-mid and pre-post time post) and the independent variables are linearly related. Before determining if a correlation exists between the dependent and the independent variables, three tests for assumptions were conducted: linear relationship, outliers, and bivariate normality. By meeting or addressing the assumptions of a test, one can ensure that the results are correctly interpreted.

Tests for Assumptions: Linearity and Outliers

First, to assess if there was a linear relationship, I created a scatterplot using the Chart Builder feature on SPSS. The pre-mid calculation scores were situated on the Y-axis and the mid-point data for the independent variables were on the X-axis. For the pre-post, calculation scores were situated on the Y-axis and the end-point data for the independent variables were on the X-axis. Six scatterplots were produced after analysis (see Appendix E, Figure E1-E6). Next, I visually assessed the scatterplots to decide whether there was enough evidence to suggest the relationships were linear (Laerd, 2018). The scatterplots that showed a monotonic relationship (i.e., when a value increases, the other values also increase/decrease, accordingly (see: Schober et al., 2018) were deemed appropriate for further testing.

Visual inspection of pre-mid calculation scores showed: (a) no linear relationship to the mid-point days of exposure variable, (b) a linear relationship to the mid-point time engaged variable, and (c) a linear relationship to the mid-point variation of movement variable. Visual inspection of pre-post calculation scores showed (a) a linear relationship to the end-point days of exposure variable, (b) a linear relationship to the end-point time engaged variable, and (c) a linear relationship to the end-point variation of movement variable. Because there were a limited number of data points available, the scatterplots did not show typical monotonic relationships.

However, the data points were grouped enough to show that a linear relationship existed. I proceeded with the following test for assumption.

The next step was to conduct a visual assessment of outliers presented in the scatterplots. For this step, I only analyzed five of the six relationships since changes in pre-mid scores and days of exposure (up to the midpoint) were not linearly related. Across the five scatterplots, eleven outliers were identified. Eight (four each) of them were found in the time engaged pre-mid and pre-post scatterplots. This is reflective of the four participants who had the lowest total time engaged. Inspection of all eleven values did not reveal them to be extreme and they were kept in the analysis. I decided to retain these regular outliers because they did not unduly influence the change scores or the conclusion of the Pearson's test.

Tests for Assumptions: Normality

To assess if the Pearson's correlation coefficient has statistical significance, a test for normality is needed to determine if bivariate normality exists. Bivariate normality is when two variables maintain a normal distribution when added together (Glen, 2022). Using the Explorer feature in SPSS, I produced Shapiro-Wilk statistics to assess bivariate normality. To determine that both variables are normally distributed, both must produce significant values greater than .05 ($p > .05$). If only one variable was found to be significant, the assumption of the bivariate normality would be violated and further tests for the pair of variables could not be conducted through a Pearson's test (King & Eckersley, 2019).

Assessment of the Shapiro-Wilk statistics produced, results showed that none of the independent variables were normally distributed when added to the dependent variables. The change in pre-mid calculation scores were significant ($p = .091$) but were not compatible with the mid-point time engaged variable ($p < .001$). Additionally, pre-mid calculation scores were not

compatible with the mid-point variation of movement variable ($p = .005$). Similarly, the change in pre-post calculation scores were significant ($p = .233$) but were not compatible with the end-point days of exposure variable ($p < .001$), the end-point time engaged variable ($p < .001$), or the end-point variation of movement variable ($p = .011$).

Though the Pearson's test is robust enough to compensate for data that are not normally distributed (Laerd, 2018), I decided not to proceed with further tests as the significance values of the independent variables were not close to the .05 cut off and any correlation found between variables would have been inconsequential. Results for all Pearson tests for assumptions can be seen in Table 7.

Table 7

Pearson's Correlation Test Results

	Correlation	Sig.
Change in pre-mid calculation		
Time engaged	0.703	<.001
Variation of movement	0.875	0.00
Change in pre-post calculation		
Days of exposure	0.827	<.001
Time engaged	0.682	<.001
Variation of movement	0.89	0.011

Social Validity Pre- and Post-Survey Results

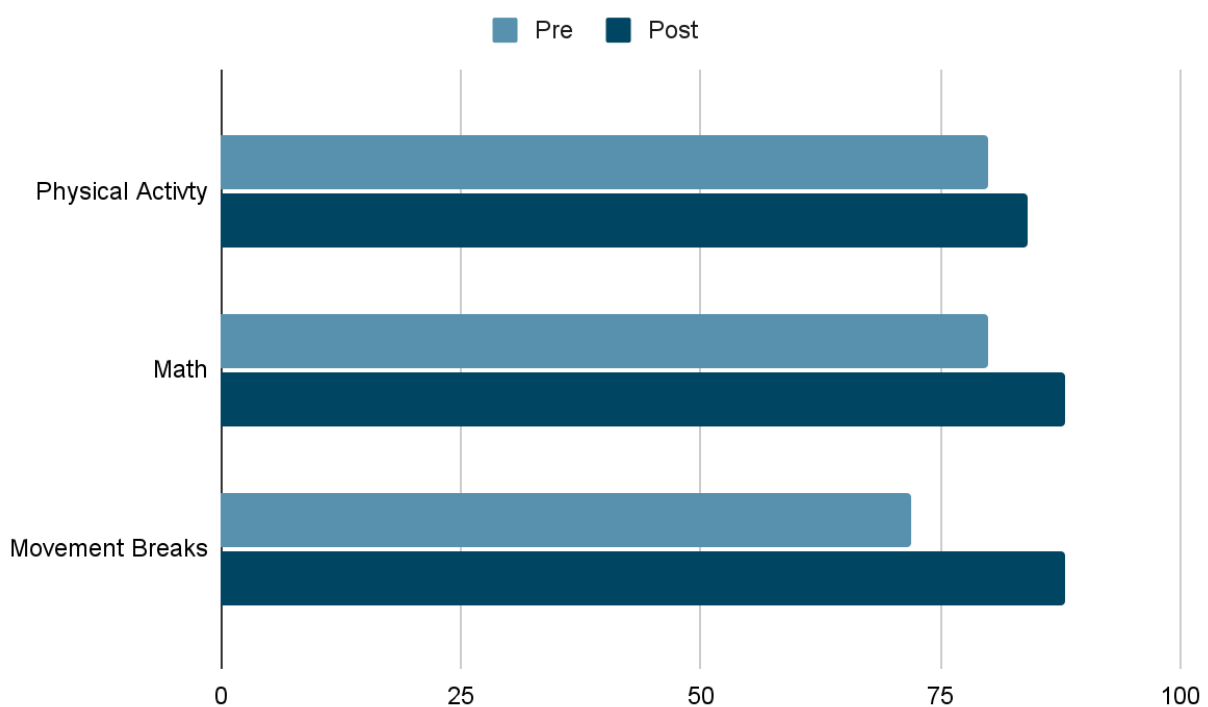
To answer research question four, *how do students with ASD respond to the GoNoodle Mega Math Marathon intervention as a tool to improve math skills?* I administered a pre- and post- survey to participants. The students were asked to rate themselves on a three-point Likert scale (yes, no, maybe) to indicate how they felt about math, physical activity, movement breaks in the classroom, and learning using GoNoodle as a whole. These are all elements of GoNoodle that the participants were exposed to throughout the study period; the participants' general perception and feelings towards the intervention tool serve as insight for incorporation of GoNoodle in future studies. There were four questions in the pre-survey: three multiple-choice questions and one open-response question. There were nine questions in the post-survey: the same three multiple-choice questions (labeled 1, 2, and 3 below) from the pre-survey were included with an additional six multiple-choice questions specific to the intervention. These six questions were added because participants had exposure to the intervention for the post-survey time.

Prior to implementing the GoNoodle Mega Math Marathon intervention most participants (80%) indicated enjoying physical activity, 80% enjoyed math, and 72% enjoyed movement breaks in the classroom. When asked how they felt about these activities after the intervention period, 84% of participants indicated enjoying physical activity, 88% enjoyed math, and 88% enjoyed movement breaks in the classroom (see Figure 6). Additionally, in the pre-survey, 72% of participants completed the write-in response to indicate the type of physical activity they engage in outside of school, if at all. Nineteen of the students responded they were walking (n = 5), run/play (n = 3), soccer (n = 3), bikes (n = 2), swimming (n = 1), baseball (n = 1), basketball

(n = 1), football (n = 1). The responses were not captured for seven participants, and one responded “yes.”

Figure 6

Students’ Self-Rated Responses on the Pre- and Post-Survey

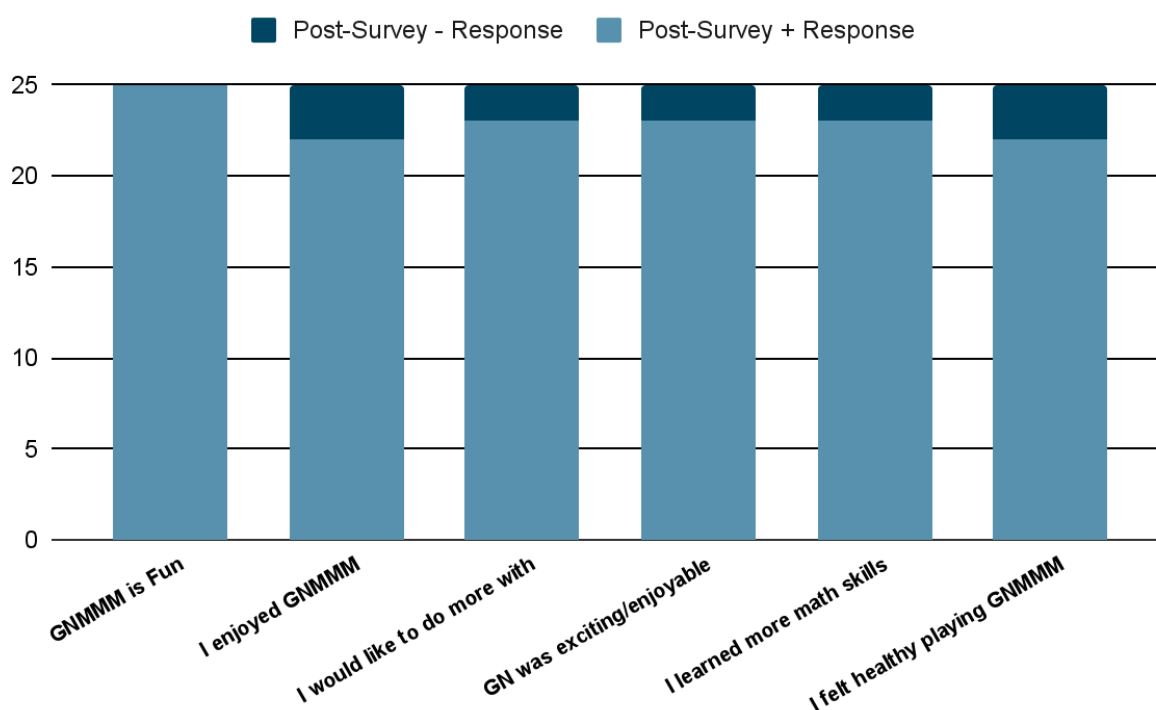


After implementation of the GoNoodle Mega Math Marathon intervention, the six additional survey questions were added to the pre-survey to create the post-survey. This information was gathered to obtain the feelings and the perceptions of the participants after they engaged in the intervention. Analysis indicated that 100% of the participants provided a positive response to the GoNoodle Mega Math Marathon intervention being fun (n = 25) and an overall positive response (88%) to the intervention tool in general (n = 22). Ninety-two percent of the participants indicated that they would like to do more GoNoodle activities, thought it was

exciting and enjoyable, and felt that they learned new math skills after engaging in the intervention (n = 23). Moreover, 88% of the participants had a positive response to feeling healthier after engaging with the GoNoodle Mega Math Marathon program (n = 22).

Figure 7

Students' Self-Rated Responses on the Post-Survey



Chapter Summary

The purpose of this study was to determine if the use of GoNoodle's Mega Math Marathon, an online interactive tool, as a mathematics intervention, resulted in improved fluency and calculation skills for middle-school aged students with ASD. The sample size for this study included twenty-five participants in grades six to eight that attend a suburban middle school in Stockton, California. To be included in this study, participants met the following criteria: (a)

attend an SDC 50% of their day for more than three years, (b) able to communicate basic wants/needs verbally, (c) able to navigate technological devices such as i-Pads, laptops, computers, and smartphones, and (d) have a confirmed primary diagnosis of ASD. The majority of the participants in this study were 12 years old ($n = 11$), in seventh grade ($n = 13$), male ($n = 22$), of either Black or African American or White race ($n = 12$ total), of Hispanic/Latino ethnicity ($n = 14$) and required level 2 supports ($n = 15$). This chapter provided an in depth look at the data collection, data analysis to include assumptions testing and results for this study.

The variables used in this study were the change scores on the *WJ-IV* assessment and (a) days of exposure, (b) time engaged, and (c) variation of movement during the GoNoodle Mega Math Marathon intervention. The instruments used in this study included two *WJ-IV* tests, the GoNoodle program, and student surveys. The social validity surveys were sent to participants prior to beginning the intervention and again post the intervention. The researcher prepared and cleaned the data by removing the identifying information after the data collection.

First, I conducted a descriptive analysis of the demographic variables and found one of the intended variables (level of ASD) was not a viable option for further analysis. Following this, I conducted assumption tests as part of the paired samples t-test procedure. The t-test results showed changes in fluency scores over time were not significant. The proceeding assumption tests for Pearson's correlation analysis showed that when variables related to the intervention were evaluated, they did not significantly impact the participant's math calculation scores. Even though the Pearson's correlation did not show statistically significant results, the social validity survey produced results of a positive nature showing that students had a positive response to the intervention.

This chapter reported the data collection process, the data analysis, and the findings. In the next chapter I provide an overall interpretation and discussion of the results. Also, Chapter 5 will provide the limitations for this study, its implications, and suggestions for future research and practice from it.

CHAPTER 5: DISCUSSION, CONCLUSION, AND RECOMMENDATIONS

Implications of Findings

The current climate of special education shows drastic disparities between grade-level achievement and academic achievement. To address this concern, this study focused on middle school-age students with autism spectrum disorder (ASD) enrolled in a Specialized Day Class (SDC). Historically, this population of students, within the Northern California Stockton Unified School District (SUSD), have presented difficulty meeting grade-level standards in mathematics (California School Dashboard, 2019). The difficulty in meeting the mathematical standards impedes on the district's initiative to have higher graduation rates for all populations (SUSD, 2022c) which is evident by "very low" score designation students with disabilities receive on standardized diagnostics (California School Dashboard, 2019). The drastic disparities between grade-level achievement and academic achievement for students in an SDC have hindered student's ability to participate in mainstream education classes without significant specialized support. This disparity could limit the possible outcome of obtaining a high school diploma (versus a certificate of completion) and living a quality life.

Two evidence-based practices focused on in this study potentially assisted students with special needs with improved mathematical skills. Exercise and movement (EXM) and technology-aided instruction intervention (TAII) have been shown to improve attention span leading to overall strengthening of mathematical skills (Steinbrenner et al., 2020; Tan, 2011). GoNoodle incorporates both EBPs and aims to increase mathematical skills through moving in place and using technology to lead the activity. Studying mathematical achievement with students with special needs, specifically Autism, is needed to find the strategies and techniques

that help close the gap between grade-level achievement and academic-achievement for our students.

This study employed an ex post facto correlational research design using extant data to identify if there was a correlation between GoNoodle, an online resource that integrates exercise and movement (EXM), and mathematical achievement for middle school students with ASD enrolled in an SDC within SUSD. Additionally, this study aimed to add to or expand on the current research on EXM as an evidence-based practice (EBP) for which there is limited existing evidence. The students included in this study were at least three grade levels behind their same-aged peers without disabilities and displayed significant deficits in mathematical achievement. I analyzed if the integration of GoNoodle's Mega Math Marathon contributed to improved academic achievement of middle school students with ASD through descriptive analysis, paired samples t-test, and Pearson's correlation. Collection and analysis of data was quantitative through means of extant data.

Summary and Interpretation of the Findings

A correlational research framework was used to explore a correlation between mathematical gains and GoNoodle, an exercise and movement (EXM) interactive online system. Hypotheses were made about this program as being a strategy to increase mathematical skills in fluency and calculation for a group of students with ASD who have moderate-to-severe support needs and receive the majority (over 50%) of their academic instruction in an SDC setting. The overall findings of my research were not statistically significant, but it did suggest there is a medium-to-large effect size in a positive direction for calculation skills. Participants elicited a mean increase of 3.800, 95% CI [.442, 7.158] from pre-test to mid-test timeframes, the difference in scores was statistically significant, $t(24) = -2.336, p = .028$. Similarly, participants

elicited a mean increase of 5.000, 95% CI [2.218, 7.782] from pre-test to post-test timeframes and the difference in scores was statistically significant, $t(24) = -3.71, p < .001$. As seen in table 8, I found that $d = .467$ (medium effect) for the pre-mid scores and $d = .742$ (large effect) for the pre-post score were significant (Laerd, 2018). There was a significant difference in calculation skills over time, but I cannot say that the other variables (level of ASD, days of exposure, time engaged, and variation of movement) influenced the outcome.

Research Question 1

“Do the math fluency and calculation scores of middle school-aged students with ASD improve over time after engaging with the GoNoodle Mega Math Marathon intervention?”

For analysis of this research question, I conducted a paired samples t-test. When I finished with the assumptions test, results for fluency test scores did not warrant strong enough outcomes so no further testing was conducted for this variable. Conversely, results for the pre-test to mid-test and pre-test to post-test showed participants' calculation scores to have a positive increase. The scores during these timeframes both elicited statistically significant mean results with medium and large effect sizes, respectively. However, the mid-test to post-test timeframes decreased and it was not statistically significant, so the mean effect size was not calculated. Moving forward, I only focused on calculation skills during the pre-test to mid-test and pre-test to post-test timeframes.

Table 8

Effect Sizes

Tests	Significant	Effect Size
Pre-test to mid-test	Yes	0.467, Medium
Pre-test to post-test	Yes	0.742, Large

Research Question 2

“Is there a correlation between math fluency scores and level of ASD, days of exposure, time engaged, and variation of movement for students with ASD who interact with the GoNoodle Mega Math Marathon intervention?”

Due to the results from the paired samples t-tests, this research question was not further investigated as the participants did not show statistically significant differences between timeframes.

Research Question 3

“Is there a correlation between math calculation scores and level of ASD, days of exposure, time engaged, and variation of movement for students with ASD who interact with the GoNoodle Mega Math Marathon intervention?”

To analyze this research question, I conducted a Pearson’s Product-Moment correlation. Descriptive statistics removed ASD as a possible independent variable since the sample size was not large enough to elicit even groups. However, I was able to see if there was a correlation between calculation skills and the other three independent variables of interest (days of exposure, time engaged, and variation of movement). Tests for assumptions informed that time engaged, and variation of movement were significant for the pre- to mid-test timeframe. Additionally, all three independent variables and the calculation scores for the pre- to post-test timeframe were significant. The final Pearson’s correlation test elicited values greater than needed to be significant for all independent variables during both timeframes.

Research Question 4

“How do students with ASD respond to the GoNoodle Mega Math Marathon intervention as a tool to improve math skills?”

The researcher-made survey questions addressed this research question. The pre-survey focused on exercise and movement and math perceptions of the participants. The post-survey included the same questions and additional questions focusing on the use of the GoNoodle resource. Overall, there was a positive response to the use of GoNoodle as a resource to learn new math skills and move more in the classroom.

Implications

The findings from this study yield three pressing implications that must be considered when identifying supports for students with ASD in improving their mathematical calculation skills. The first implication resulting from this study relates to the levels that students with ASD are often grouped into (i.e., level 3, 2, or 1), according to the *DSM-V*. The *DSM-V* “provides a common language for researchers to study the criteria for potential future revisions and to aid in the development of medications and other interventions” (APA, 2013). Three subtypes of ASD have been described according to the *DSM-V* in this study and were used to understand whether the GoNoodle intervention had an impact on student outcomes by level of ASD. In short, the three levels are 3 “requiring very substantial support,” 2 “requiring substantial support,” and 1 “requiring support. ”

Following the *DSM-V* guidance, I hypothesized that level of ASD would be associated with mathematical achievement outcomes. However, the findings relating to this study to identify differences in intervention effects by the level of need were not analyzed. I found through descriptive analysis that the participant pool was too small to adequately measure differences between levels of ASD as a contributing variable to mathematic skills growth. Literature reviewed for this study focuses on higher achieving students with ASD (i.e., level 1) who are already included in the general education setting (Jitendra et al., 2015; Root & Browder,

2017) meaning, known mathematical interventions and supports for students with ASD are not designed for students who have higher support needs (i.e., level 3 and 2). Given the results of this current study, it is not yet known if the level of ASD plays a significant role in the outcome of improved mathematical skills and knowledge. Because the number of individuals with disabilities and individuals with ASD are limited, compared to the population of individuals without disabilities, issues relating to sample size may continue to be of concern when determining the effectiveness of an intervention tool such as GoNoodle. This is especially true if the aim is to understand if the level of ASD plays a role in the outcome. Therefore, future research with students with ASD should include additional variables that may better indicate effectiveness or impact of an intervention on an outcome, such as days of exposure and time engaged in the intervention which proved to have an effect in this study even though they were not significant overall. Further implications on the sample size are discussed in the limitations and future research sections below.

A second implication investigated the use of persistent practice, schema-based instruction (evidence-based practices which support mathematical understanding), and virtual manipulatives for enhanced mathematical achievement of students with ASD. Using GoNoodle as the intervention provided a virtual manipulative, along with schema-based instruction. The use of persistent practice of the intervention was shown from the intervention being delivered daily for 5-minute sessions. These three strategies combined have shown to improve mathematical skills (Park et al, 2020; Peklari, 2019; Root & Browder, 2017). Findings for mathematical achievement in this study, using these strategies, through use of GoNoodle, did not show statistically significant results for fluency or calculation. However, there were positive effect sizes for calculation from the pre-post timeframe. Although this study was constructed with

protocols for fidelity, ensuring the study intervention steps are followed as designed for all participants, instilling such measures is not common or in many cases, feasible within all classrooms. Educators of students with ASD and other disabilities often must balance time needed to learn and master material with district or school-specific requirements such as state testing, school events, and keeping up with curriculum timeline, all influencing the key factors to improve mathematical skills, like persistent practice. To address this challenge, school districts need to allow teachers time to plan for persistent practice. Teachers have access to schema-based instruction and virtual manipulatives, but time is the bigger challenge in providing persistent practice and being able to focus on mathematical skills for students with ASD.

A third implication investigated the possibility of extending current knowledge of evidence-based practices (EBPs). The technology-aided instruction and intervention (TAII) EBP is universally identified and can be used effectively to address communication, social, cognitive, school readiness, adaptive/self-help, challenging/interfering behaviors, and motor. The exercise and movement (EXM) EBP has not been universally recognized as an EBP even though exercise can be used to improve performance with a task or behavior, or to increase physical fitness and motor skills. The variation of movement was analyzed within this study and it did not show statistically significant results for fluency or calculation scores. For significant strides to be made in math and functioning, support in and out of the classroom can only be done through research and studies with fidelity and higher outcomes. Technology plays a huge role in educational outcomes with curriculum materials being located and accessible through a laptop. More time and resources need to be allocated to further research of EBPs effectively. Variation of movement could play a role in increased mathematical achievement if educators, districts, and families allotted more time and persistent practices to this initiative.

Overall, this study did not show statistically significant differences for the use of GoNoodle to improve fluency and calculation skills for middle-school aged students with autism. Effect size was medium to high in the t-test therefore future studies may elicit a correlation by a larger sample size and a longer duration of study. There are factors that need to be adequately understood and studied to better support students with ASD and math skills. While there has been work done in this area, more research and studies need to be conducted to close the gap between grade-level and academic achievement.

Limitations of the Study

There were several limitations associated with this study that could have affected the outcome. Due to external factors such as the environment, sample size available, and constrained timeframe, results of this study cannot be generalized to other populations. However, considering such limitations in future studies could lead to more generalizable findings.

External Environment

The intervention took place in two different SDC classrooms located on a public-school site which serves a majority general education student population; thus, I was not able to control for distractions such as intercom interruptions, visitors, visual effects of the intervention, sound, and lighting. One student said they were not participating in the first two sessions because the intervention was too loud. I made accommodations for this by moving the student further away from the speakers and lowering the volume. If students were targeting one another (intentionally trying to upset another student), I relocated them to different areas of the classroom. I minimized visitor distractions by keeping the doors locked. To adjust the lighting as needed, I turned them off, closed the blinds, or adjusted the projector settings. In response to previous behaviors that a

student may have been dealing with, I provided a mindfulness activity to redirect and/or reminded them about the reward system in place for their participation in the intervention. After reviewing student results, behaviors or emotional state of mind affected the participant's ability to focus on the assessment and apply their best work. The 'best time of day' to deliver the intervention was something I could not control since this was a large group process. These instances related directly to the outliers found in the analysis thus choosing to keep all outliers throughout the research.

Sample Size

This study only examined 25 middle school-aged students with autism. The levels of ASD were not evenly represented across grade levels or age thus challenging the generalizability of the results. Due to the immediate need to understand strategies to help students with special needs (SWD) close the achievement gap, the intervention took place on a single campus encompassing two classrooms that housed middle school-aged students with ASD. If possible, future research could be conducted with a larger population to the scope of an entire district or a county.

Timeframe

This study only tracked 20 sessions at 5 minutes each totaling 100 minutes of engagement. Data was extant due to the pressing need to close the academic achievement gap. I decided to implement the assessments and the intervention at the end of the school year because the need to provide math interventions and support to the students in the SDC setting were immediate. Waiting for a new school year would have prolonged the opportunity for further study in this area to expand on EBPs and additional support in this setting.

Social Validity Survey

The survey was researcher-made and implemented. Students may have needed additional staff support to fill out the survey, which may have skewed the response if the participant needed further explanation of the questions. Questions focused on the objectives of exercise and movement, mathematical enjoyment, and GoNoodle perceptions.

Recommendations and Future Research

The purpose of this quantitative correlational study sought to assess if the use of GoNoodle's Mega Math Marathon, an online interactive tool, as a mathematics intervention for middle-school aged students with ASD resulted in improved fluency and calculation skills as an attempt to minimize the educational gap between grade-level and academic achievement for students with ASD. The results of this study showed a not statistically significant correlation between the variables across all combinations. Future researchers should consider a case study research design to narrow in on effects of the intervention according to ASD level since every student with autism is on an individualized education plan. However, I have provided explanations and recommendations and future research of this study's design below.

External Environment

To address concerns of the external environment on distractions and visual, lighting, and sound effects, the location of the intervention could take place in a larger community room with minimal windows, entrances, and interference. The program itself could have more settings to change the music options and background scene to be more subtle, as well as more options to select the specific math skills that are being studied. Additionally, addressing behaviors that may arise, time of day may be considered if the intervention is implemented at numerous times of the day or assess students later when they are at baseline.

Independent Variables

This study analyzed variables that were incorporated in the extant data collection. These presented limitations in factors that were correlated to improved mathematical achievement. Future research should consider how these variables are interrelated and affect one another. Future iterations of this study should also consider additional variables such as individual health (e. g., BMI, sports involvement) of participants and individual or group engagement plays a significant factor for this population of students because socialization is a known area of need for students with autism.

Sample Size

My sample size was exceedingly small (n=25) due to the constraints of enrollment at this school site. Future research could incorporate more participants if multiple teachers are invested in a larger scale of district or county enrollment. A larger sample size could allow for a breakdown of participants by ASD level to see if there were any significant effects between levels.

Timeframe

This research's timeframe was limited, only having a maximum of 20 data points for each participant, and only tracking a maximum of 100 minutes throughout the 30-day period. This considered absences thus some students did not engage or have exposure to all 20 sessions of the intervention (20 days exposure n=8; 19 days exposure n=5; 18 days exposure n=6; 17 days exposure n=3; 15 days exposure n=1; 14 days exposure n=1; 13 days exposure n=1). Future research could have a “make-up” session(s) to make sure all participants were exposed for the same amount of total time and sessions. Furthermore, the research could extend to a longer timeframe such as a semester or a full schoolyear. The data showed that pre-post testing had the

greatest improvement (even though it was not statistically significant) so I can only assume that extending the timeframe for a future study would yield a greater effect.

Social Validity Survey

The student survey was teacher/researcher-made to focus on the participant response to the GoNoodle intervention and overall outlook on exercise and movement. Results to use of this tool were of a positive nature, even though statistical significance was not shown. It would be interesting to see if a program like virtual reality using other exercise and movement activities incorporated with math skills would yield a significant result. For instance, in the survey, other sport interests were logged in the responses, like swimming. A virtual reality game could be designed to incorporate swimming motions, to complete a 100-meter race, by answering math questions and fastest time wins.

EBPs

This study as is, was not able to yield significant results which could add to existing literature and strategies for improving math skills for middle school-aged students with autism. However, future research could consider these changes to expand on exercise and movement to be considered an evidence-based practice by the National Professional Development Center (NCAEP) and the National Standards Project (NSP).

Chapter Summary

This study focused on mathematical achievement of middle-school aged students with autism through means of an online resource, GoNoodle, which incorporated exercise and movement into the curriculum. This study was done in hopes of being a valuable tool for increasing mathematical skills to close the gap between grade-level achievement and academic achievement for students with ASD. The overall outcomes were not as high as one would hope

with a study done with fidelity and persistence, but it still offers a positive opportunity for learning and improving math skills.

Using GoNoodle in the classroom was a positive, fun, and exciting experience for the majority of the participants involved. Scores for calculation did improve from the start of the study to the finish of the study but they were not deemed statistically significant. This does not mean that the resource is invaluable. Small gains matter in all areas of education. GoNoodle can still be a valuable tool for improving calculation skills in the classroom, at home with families, and as a district initiative for students with special needs.

As a professional in the education world, it is important to incorporate effective strategies for learning with student buy-in. This tool proved to be a promising strategy for students to be engaged, interested, and excited about learning mathematical skills within this specific population of participants. More research is needed to address the educational gap and to provide better opportunities for SWD to live a healthy lifestyle and build an era of productive members of society.

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Appendix B: Student Survey Post Intervention

GoNoodle Student Perspective

Click the response that best represents the way you feel about GoNoodle Mega Math Marathon sessions.

* Required

1. GoNoodle Mega Math Marathon is fun. *

Mark only one oval.

- Yes
 No
 Maybe

2. Do you enjoy physical activity? *

Mark only one oval.

- Yes
 No
 Maybe

3. I felt healthy playing GoNoodle Mega Math Marathon. *

Mark only one oval.

- Yes
 No
 Maybe

4. I learned more math skills playing GoNoodle Mega Math Marathon. *

Mark only one oval.

- Yes
 No
 Maybe

5. I enjoyed playing GoNoodle Mega Math Marathon. *

Mark only one oval.

- Yes
 No
 Maybe

6. GoNoodle Mega Math Marathon was exciting and enjoyable. *

Mark only one oval.

- Yes
 No
 Maybe

7. I would like to do more activities with GoNoodle. *

Mark only one oval.

- Yes
 No
 Maybe

8. Do you enjoy math? *

Mark only one oval.

- Yes
 No
 Maybe

9. Do you enjoy movement breaks in the classroom? *

Mark only one oval.

- Yes
 No
 Maybe

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Appendix C: Student Survey Pre-Intervention

Student Perspective

Please mark your answer to each question.

1. Do you enjoy physical activity?

Check all that apply.

- Yes
 No
 Sometimes

2. Do you enjoy math?

Check all that apply.

- Yes
 No
 Sometimes

3. Do you enjoy movement breaks in the classroom?

Check all that apply.

- Yes
 No
 Sometimes

4. What, if any, physical activities do you participate in outside of school?

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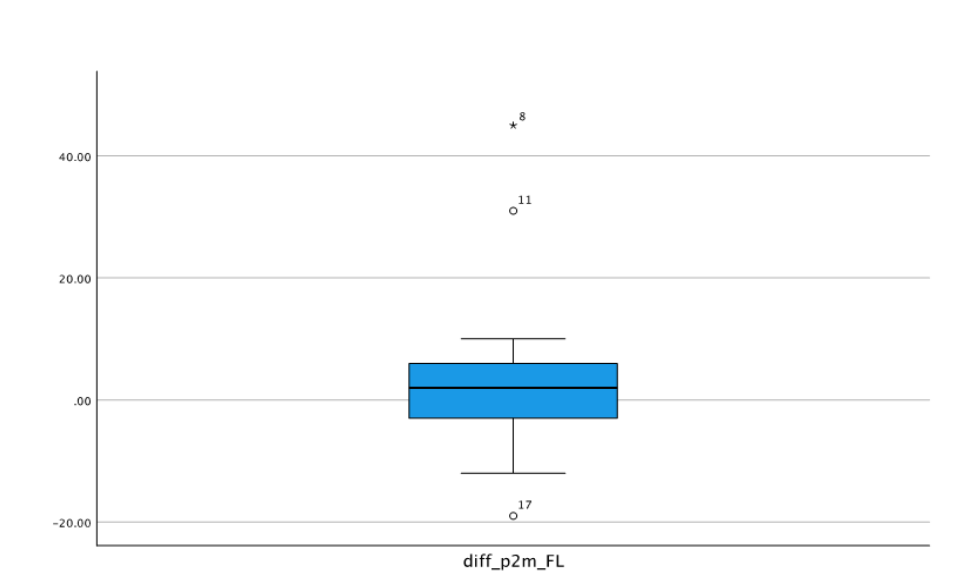
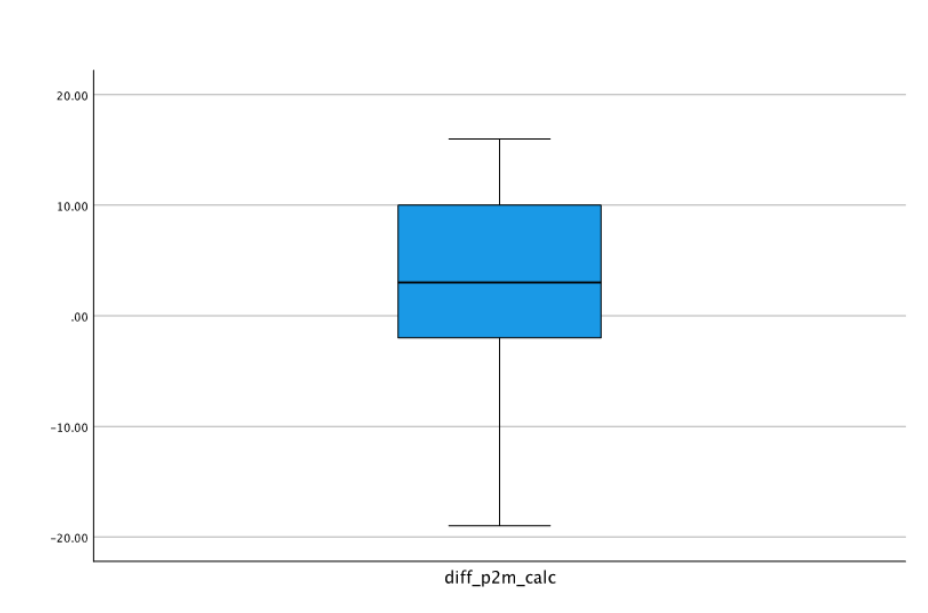
Appendix D: Paired Samples Tests for Assumptions: Outliers**Figure D1***Difference Scores Pre-Mid Fluency***Figure D2***Difference Scores Pre-Mid Calculation*

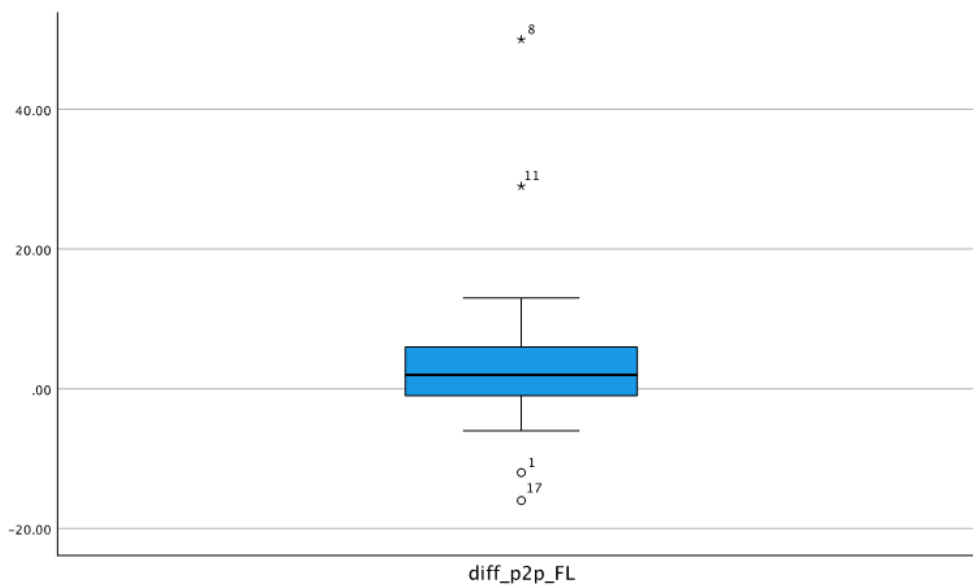
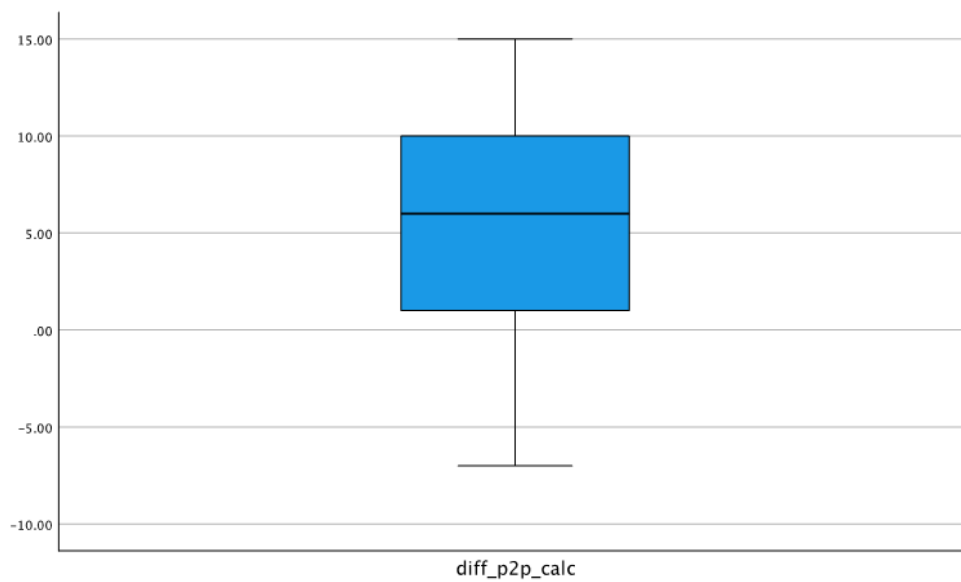
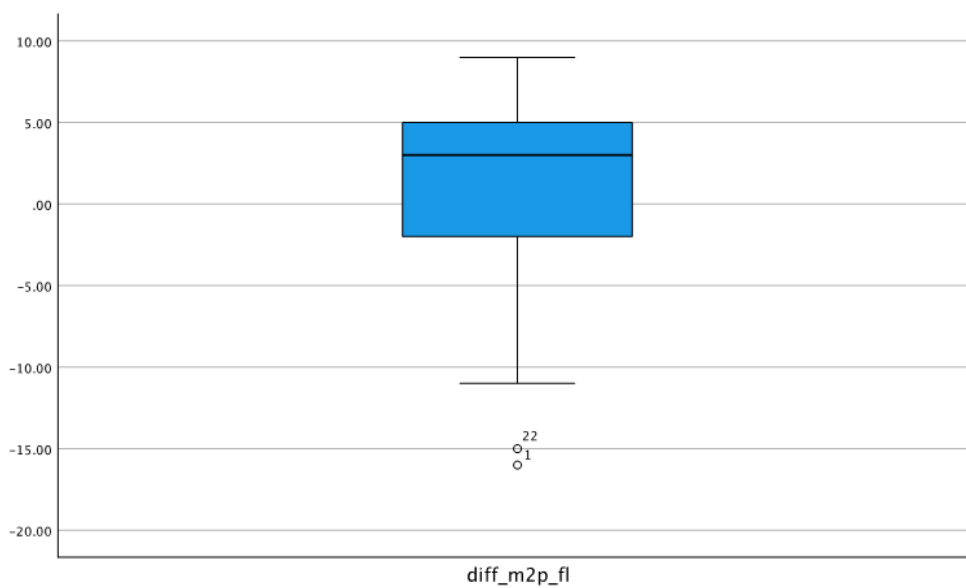
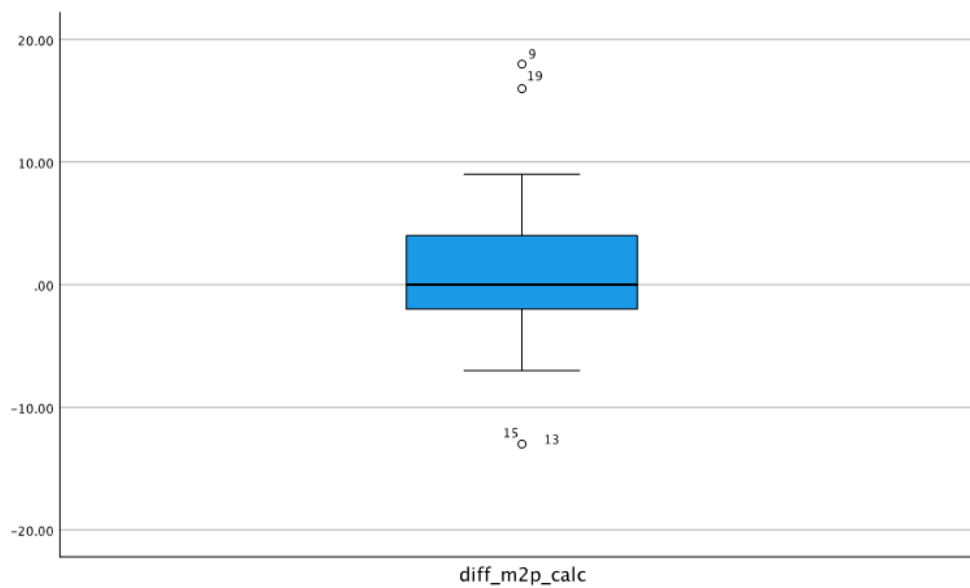
Figure D3*Difference Scores Pre-Post Fluency***Figure D4***Difference Scores Pre-Post Calculation*

Figure D5*Difference Scores Mid-Post Fluency***Figure D6***Difference Scores Mid-Post Calculation*

Appendix E: Pearson's Scatterplot

Figure E1

Pearson's Scatterplot Pre-Mid Test Calculation Days Participation

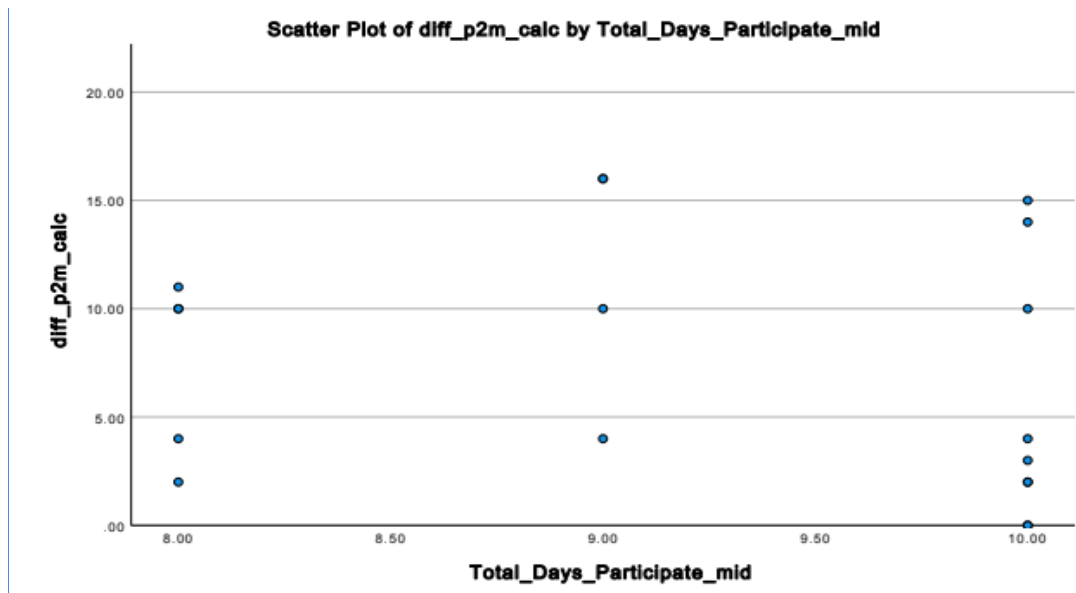


Figure E2

Pearson's Scatterplot Pre-Mid Test Calculation Active Minutes

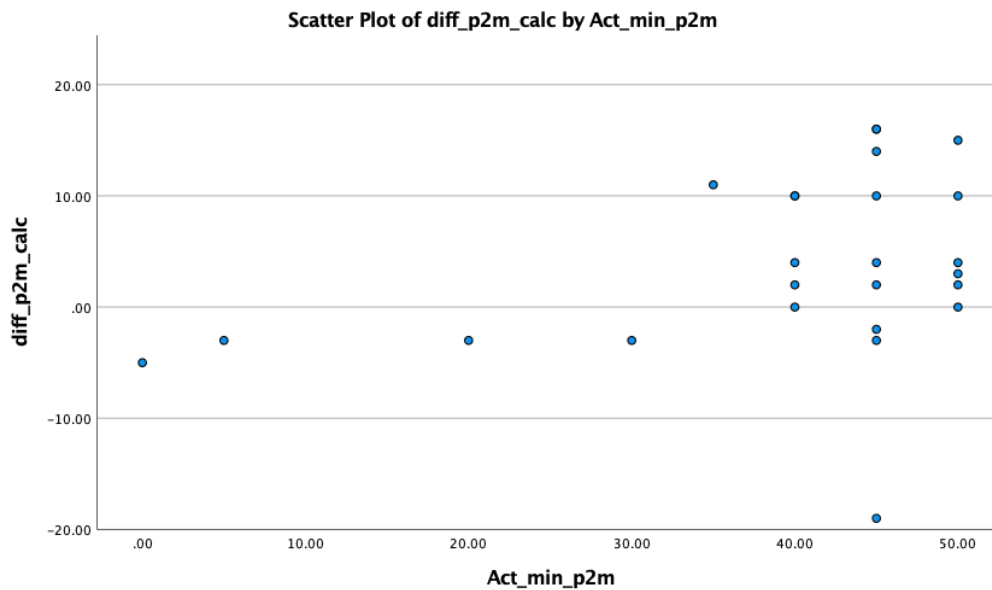


Figure E3

Pearson's Scatterplot Pre-Mid Test Calculation Average Movement

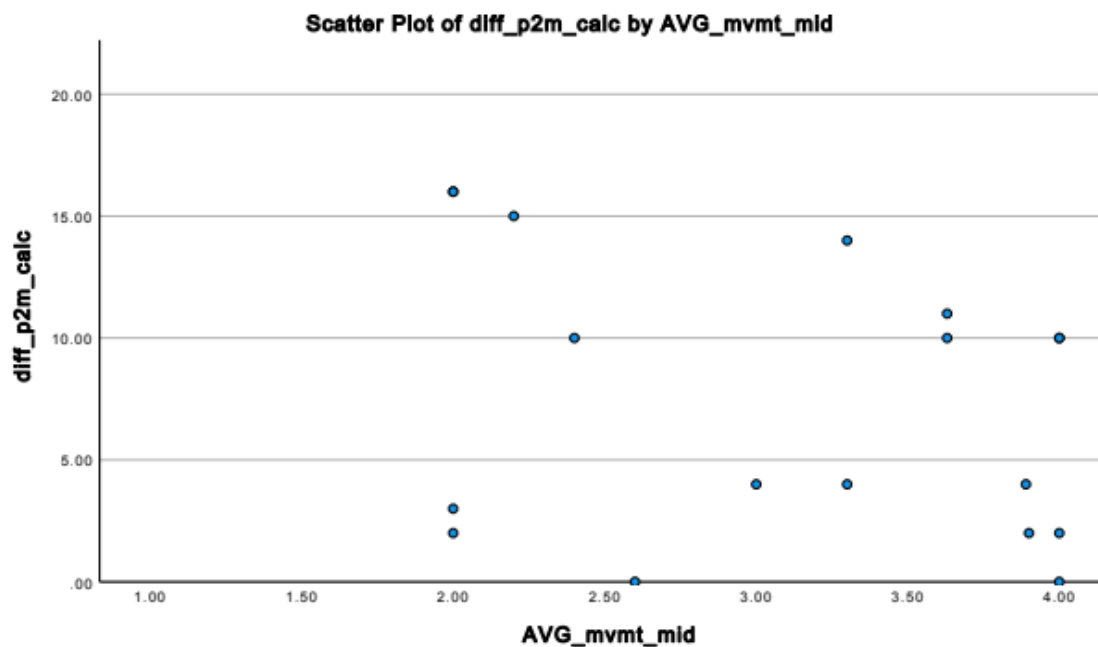


Figure E4

Pearson's Scatterplot Pre-Post Test Calculation Days Participation

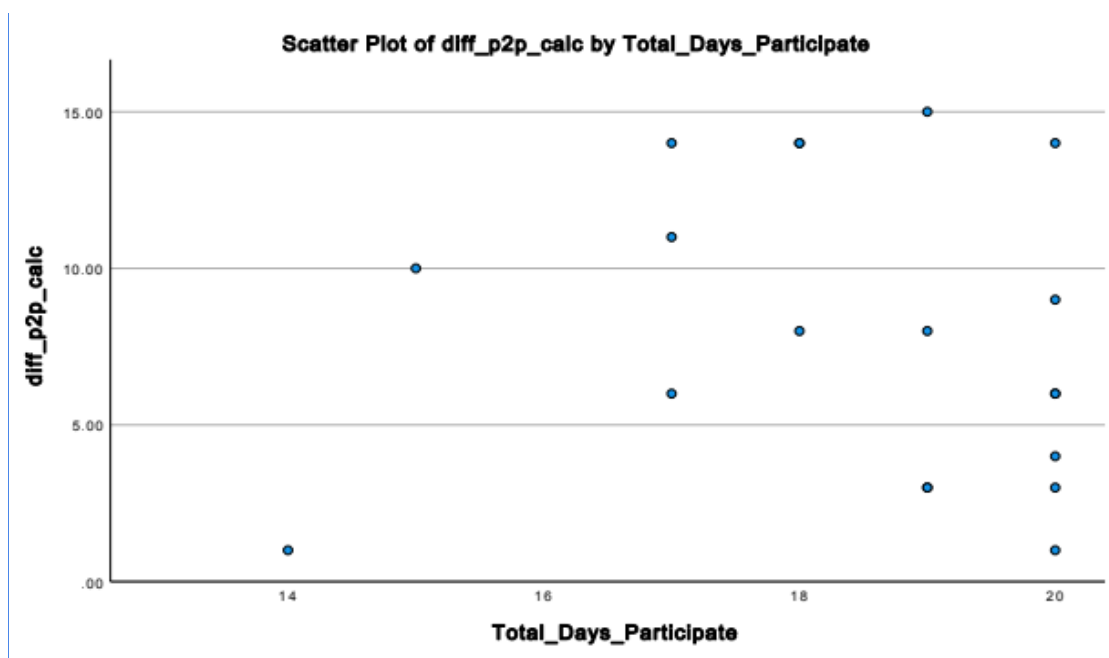
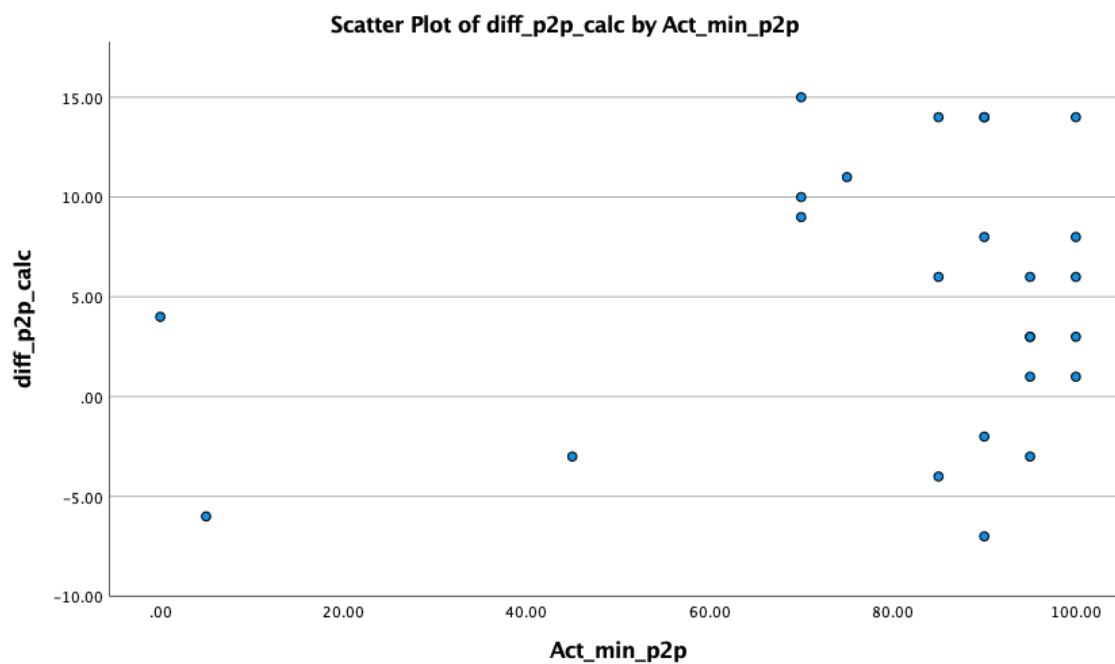


Figure E5*Pearson's Scatterplot Pre-Post Test Calculation Active Minutes***Figure E6***Pearson's Scatterplot Pre-Post Test Calculation Average Movement*