THE CAUSAL-COMPARATIVE ANALYSIS OF ACADEMIC PERFORMANCE OF HIGH SCHOOL STUDENTS WITH AND WITHOUT DISABILITIES IN THE FACE-TO-FACE AND ONLINE EDUCATIONAL SETTINGS

by

Marina V. Clayton

Liberty University

A Dissertation Presented in Partial Fulfillment

Of the Requirements for the Degree

Doctor of Philosophy

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APPROVED BY:

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ABSTRACT

The purpose of this non-experimental causal-comparative study was to determine whether there is a statistically significant difference in the academic performance of high school students with and without disabilities who received math instructions in face-to-face and online educational settings during the 2020-2021 school year. During that year, educational establishments worldwide transitioned from traditional face-to-face to online delivery mode, complying with the social distancing requirements due to the COVID-19 pandemics. The current study employed a convenience sample that consisted of 588 high school students from Georgia. Participants took the Georgia Milestones End-of-Course Test in Algebra I in the spring of 2021 after receiving math instructions in the online or face-to-face settings. The researcher used this test as the instrument and compared the participants' scores. A two-way analysis of variance was used to examine the differences among six groups of students based on their disability status and the number of semesters taken online. The findings revealed that students with disabilities exhibited lower academic performance in math compared to their general education peers. Additionally, the study suggested that the transition to online learning during the COVID-19 pandemic had a negative impact on learning outcomes for all participants. However, the study did not find a significant interaction between students' disability status and the number of online semesters in relation to their academic performance. The limitations of the study included the specific population and quasi-experimental design. Recommendations for future research addressed the factors that may affect students' learning outcomes in online and face-to-face settings.

Keywords: Academic performance, educational settings, online learning, face-to-face instructions, delivery method, students with disabilities

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Dedication

This dissertation is dedicated to the following people, who have been instrumental in my academic journey.

I extend my deepest gratitude to my dear husband, whose constant encouragement and belief in my abilities have been a source of my motivation and inspiration. I am grateful for your role in my pursuit of this PhD and your presence in my life.

To my young grandchildren, who have shown genuine interest in my studies, I am grateful for the joy and enthusiasm you have brought to this endeavor. Your curiosity and excitement have reminded me of the importance of lifelong learning.

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List of Abbreviations

American Educational Research Association (AERA)

American Psychological Association (APA)

Analysis of Variance (ANOVA)

Attention-Deficit and Hyperactivity Disorder (ADHD)

Autistic Spectrum Disorder (ASD)

Center for Applied Special Technologies (CAST)

Computer-based technologies (CBT)

Coronavirus disease of 2019 (COVID-19)

Criterion-Referenced Competency Test (CRCT)

Cultural-historical activity theory (CH/AT)

Data Recognition Corporation Education (DRC INSIGHT)

Early Childhood Education (ECE)

Emotional/Behavioral Disorders (EBD)

Georgia Department of Education (GA DOE)

Georgia End-of-Course test (GA EOC)

Georgia Standards of Excellence (GA GSE)

Georgia Statewide Longitudinal Data System (GA SLDS)

Grade Point Average (GPA)

Grade Conversion Scores (GCS)

Individualized Educational Program (IEP)

Individuals with Disabilities Education Act (IDEA)

Information and communication technologies (ICT)

Institutional Review Board (IRB)

Learning Disabilities (LD)

Learning Management System (LMS)

Least Restrictive Environment (LRE)

Massive Open Online Courses (MOOC)

Mathematical Learning Disability (MLD)

Mild Intellectual Disability (MID)

More Knowledgeable Other (MKO)

National Center for Education Statistics (NCES)

National Council on Measurement in Education (NCME)

Online Assessment System (OAS)

Other Health Impairments (OHI)

Science, Technologies, Engineering, and Math (STEM)

Specific Learning Disabilities (SLD)

Speech-Language Impairment (SLI)

Standard Error of Measurement (SEM)

Statistical Package for the Social Sciences (SPSS)

Students with Disabilities (SWD)

Universal Design for Learning (UDL)

Zone of Proximal Development (ZPD)

CHAPTER ONE: INTRODUCTION

Overview

Multiple researchers have examined the effectiveness of different academic settings in general and special education. However, their findings have often been contradictory. While some insisted that students demonstrate higher academic achievements in the face-to-face setting, others argued that online and blended settings are more efficient and effective, especially for students with disabilities (SWD). The purpose of this non-experimental causal-comparative study was to determine whether there is a statistically significant difference in the academic achievements of high school students (with and without disabilities) after receiving math instruction in different academic settings. The first chapter of this manuscript presents a historical overview, social impact, and theoretical framework of the problem. It also includes the problem statement, purpose of the study, its significance, research question, and definitions of relevant terminology.

Background

In the spring of 2020, due to the Coronavirus Disease of 2019 (COVID-19) pandemic, distance learning became a necessary part of education worldwide (Kulikowski et al., 2022). To comply with the obligatory social distancing requirements, students in different countries swiftly transitioned from in-person classrooms to online instructions (Anderson et al., 2021; Kulikowski et al., 2022). Currently, education stakeholders discuss the impact of these measures on various groups of students, including at-risk and students with disabilities (SWD). Several research groups reported that SWD and at-risk students were significantly impacted by this involuntary transition from face-to-face to online learning (Halloran et al., 2021; Sass & Goldring, 2021). For instance, Halloran et al. (2021) stated that students from all categories demonstrated significant

learning loss in all academic areas after switching to online learning during the pandemic-related school shutdowns. Furthermore, Sass and Goldring (2021) found decreased achievement growth in students of all ages, regardless of their disability status. The purpose of this study was to compare the mathematics performance of high school students with and without disabilities in different academic settings. The sociocultural theory of human development (Vygotsky, 1962; Vygotsky, 1978) served as a theoretical framework for the current research study. The next section presents the historical, social, and theoretical contexts of this theory.

Historical Overview

Since the 1970s, when computer-based technologies (CBT) became a valuable tool in education, their role in the special education classrooms significantly changed. From assistive tools, CBT evolved into information and communication technologies (ICT), helping students to acquire academic knowledge and practice skills required by the modern computerized society (Alaniz et al., 2017; Clark & Mayer, 2016; Waxman et al., 2003; Wise, 2019). With the help of ICT, students can control their own pace of learning, order of assignments, and accessibility tools (Miranda et al., 2017). Also, ICT can facilitate the scaffolding processes and independent implementation of individual accommodations without an instructor's assistance. Furthermore, Wise (2019) reported that students experience less stress during online testing in comparison with traditional paper-pencil tests. In addition, both students and teachers reported that they appreciate academic mobile learning and games in special education for their positive educational and motivational influences (Hwa, 2018; Walker et al., 2017; Wise, 2019).

Despite various positive outcomes from implementation of ICT, researchers noted that some students experienced such negative effects as cognitive overload, disengagement, and increased testing anxiety during digital-based learning (Kim & Huynh, 2008; Lucky et al., 2019;

Wise, 2019). In addition, Lucky et al. (2019) and Wise (2019) reported frequent cases of academic dishonesty among online learners. Researchers also named several other drawbacks, such as the excessive cost of equipment, software, and maintenance of ICT (Alaniz et al., 2017; Clark & Mayer, 2016). These contradictory reports about the effectiveness of ICT in education call for additional research and analysis. One of the under-investigated areas that combines academic interest and social concerns is the application of ICT in special education in different academic settings (Alaniz et al., 2017; Clark & Mayer, 2016; O'Brien & Beattie, 2017).

Society-at-Large

In 2019, approximately 14% of students in K-12 public schools in the United States of America (USA) received special education services (NCES, 2021). The Individuals with Disabilities Education Act (IDEA, 2004) is the federal law that mandates inclusion of SWD into the general student population to the maximum possible extent. The Least Restrictive Environment (LRE) is the special education continuum of services that classifies educational settings for SWD, depending on the amount of special education support provided to learners (IDEA, 2004; Lemons et al., 2018; O'Brien & Beattie, 2017). Co-teaching, paraprofessional support, and small group resource classes are among the most common settings (IDEA, 2004; Lemons et al., 2018; O'Brien & Beattie, 2017). Settings, such as self-contained classes, special schools, hospital schools, and homebound services, provide special education services to SWD with critical needs (IDEA, 2004; O'Brien & Beattie, 2017). The Individualized Education Program (IEP) is a legal document that describes the type and extent of the special education services provided to each child with a disability (IDEA, 2004). Based on the student's present levels of performance, the IEP determines the developmental goals, accommodations, and

educational settings that should facilitate adequate progress appropriate to the child's abilities and circumstances.

Traditionally, the LRE considered face-to-face setting as the default modality of instructions delivery for SWD (IDEA, 2004). Later, CBT and ICT enhanced the learning process by generating blended learning, in which instructors combine face-to-face and online activities (Alaniz et al., 2017; Clark & Mayer, 2016; Erbil, 2020; Lu et al., 2018; Mullen, 2020; Sweller et ai., 2011; Thai et al., 2019). For the purposes of the IEP, both settings are equivalent and do not require special regulations except for the state-mandated tests. However, a fully online setting is a notable change in placement. That is why the IEP must provide a rationale for this change and specify appropriate support, goals, and accommodations for SWD (O'Brien & Beattie, 2017).

In the spring of 2020, due to the COVID-19 social distancing mandates, public schools in the USA rapidly moved from face-to-face to fully online instruction. Consequently, special education teachers in Georgia had to amend the IEPs for all SWD to be compliant with the federal law. In addition, Georgia Department of Education (GA DOE) waved all state-mandated tests for the 2019-2020 school year, attempting to mitigate possible negative effects of this involuntary transition on students' academic outcomes and general well-being (GADOE, 2020d). Several recent studies reported that students with and without disabilities indeed demonstrated significant learning loss after receiving instructions in the fully online settings during school shutdowns (Halloran et al., 2021; Kulikowski et al., 2022; Sass & Goldring, 2021). These reports contradicted multiple previous findings that the online setting is beneficial for students' academic outcomes, course satisfaction, and their emotional well-being, regardless of their disability status (Cinquin et al., 2019; Dendir, 2018; Kent et al., 2018; Kotera et al., 2019; Miranda et al., 2017; Sublett & Chang, 2019).

The lack of congruency in the body of research on the topic created the need for additional investigation. The goal of the present study was to compare the academic performance of high school students with and without disabilities who received math instructions in different academic settings during the school shutdowns related to the COVID-19 pandemic. There is also a gap in professional literature that could give a theoretical explanation for this phenomenon. The most appropriate theory should provide several crucial factors that may influence learning outcomes depending on the instructional delivery method and the students' disability status. That is why Vygotsky's sociocultural theory of human development (Vygotsky, 1962), due to its multidisciplinary character, served as the theoretical framework for the present study.

Theoretical Background

Vygotsky's theory of sociocultural development (Vygotsky, 1962; Vygotsky, 1978) is one of the most popular frameworks for research studies in present-day education and psychology (Dafermos, 2018; Valsiner, 2021; Van der Veer, 2021). The dramatic socio-historical events during Vygotsky's lifetime and the findings of other scientists and philosophers shaped his views and influenced his work (Valsiner, 2021; Van der Veer, 2021; Vasileva & Balyasnikova, 2018; Yasnitsky, 2018a). In his theory, Vygotsky (1962) stated that learning precedes development and happens through social interaction with a more knowledgeable other (MKO). The MKO can be a parent, a teacher, a peer, or an unanimated source of information such as texts and images (Vygotsky, 1962; Vygotsky, 1978). In a modern society filled with multimedia, various ICT can serve as the MKO (Erbil, 2020). That is why Vygotsky's ideas are applicable as a theoretical foundation for the present research study.

The MKO assists learners in acquiring new knowledge and skills through scaffolding (Bruner, 1986). Bruner defined scaffolding as the process of deconstruction of large educational

tasks into smaller manageable assignments. Scaffolding takes into consideration a student's zone of proximate development (ZPD), which is the set of activities that this student can complete with the help of the MKO (Vygotsky, 1962; Vygotsky, 1978). Vygotsky (1962) maintained that a learner's success depends on the MKO's scaffolding and instructional skills. In the case of ICT, scaffolding is an embedded part of online instructions (Alaniz et al., 2017; Clark & Mayer, 2016; Erbil, 2020). Miranda et al. (2017) noted that students benefit from online learning when they independently scaffold the content, control their pace, and choose the order of assignments.

Many scholars worldwide supported and extended Vygotsky's ideas (Clara, 2017; Dafermos, 2018; Roth, 2020b; Sikhova et al., 2020; Van der Veer, 2021). They also used his theory to create their own theoretical systems. Among them was Luria, who established the foundations for cross-cultural studies and neuroscience (Glozman, 2018; Luria, 1931; Luria, 1933; Luria, 1976). Another follower of Vygotsky, Leontiev, developed the activity theory that eventually evolved into the cultural-historical activity theory (CH/AT) (Dafermos, 2018; Engestrom, 1987; Leontiev, 1976). Vygotsky's works in pedology provided the theoretical basis for present-day educational psychology and special education (Vygotsky, 1931; Sikhova et al., 2020).

Vygotsky's interdisciplinary theory is still relevant in education, psychology, neuroscience, sociology, and cross-cultural studies. Currently, scholars continue to develop the concepts of ZPD, MKO, scaffolding, and group ZPD (Bernstein, 1961; Bruner, 1986; Clara, 2017; Daniels & Tse, 2021; Donato, 1994; Eun, 2019; Hedges, 2021; Kim et al., 2021; Shvarts & Bakker, 2019; Wood et al., 1976). The CH/AT theory (Dafermos, 2018; Engestrom, 1987; Leontiev, 1976) employed Vygotsky's ideas as a foundation for the paradigm that explained human cognitive development during various activities, including communication with people

via non-verbal methods, gamification, and social-media platforms. Cross-cultural studies and educational research frequently use sociocultural principles in a differential approach to testing and instructions (Hedges, 2021; Smolucha & Smolucha, 2021). Many scholars have investigated the roles of the educational environment, instructions, and teacher's instructions from the sociocultural theory point of view (Clara, 2017; Daniels & Tse, 2021; Eun, 2019; Hedges, 2021; Kervinen et al., 2020; Smolucha & Smolucha, 2021).

According to Vygotsky (2017), the highest level of cognitive development is based on self-regulation and self-development. Researchers frequently combine this approach with Bandura's concept of self-efficacy to study academic performance in learners of various ages (Eun, 2019). Vygotsky's theory served as a foundation for three intertwined disciplines, namely, neuroscience, elementary childhood education (ECE), and special education (Hedges, 2021; Sikhova et al., 2020; Smolucha & Smolucha, 2021). In addition, scholars often use Vygotsky's theory as a theoretical framework in their studies on math education (Ng, 2021; Roth, 2017; Roth, 2020d; Seleznyov et al., 2021; Walshaw, 2017). Finally, Vygotsky's theory is applicable when various multimedia technologies and ICT work as the MKO by combining the functions of an instructor, a tool, and an environment (Alaniz et al., 2017; Erbil, 2020; Eun, 2019).

To summarize, many modern researchers agree that Vygotsky's sociocultural theory of cognitive development is still a working instrument for explaining and predicting various phenomena in psychology, sociology, and education (Dafermos, 2018; Valsiner, 2021; Van der Veer, 2021). The current study used the following key points of this theory. First, Vygotsky (2017) emphasized the role of communication with the MKO for cognitive development of learners. Next, Luria (1976) established that deficits in human interactions can cause cognitive malfunctioning in humans. Also, Leontiev (1978) used Vygotsky's ideas to demonstrate how

various activities affect psychological and cognitive development in children of different ages. The goal of the present study was to compare the academic performance of students, with and without disabilities, whose access to communication with the MKO differed depending on their choice of the educational setting. Vygotsky's theory of sociocultural development, which takes into consideration all these factors, served as a theoretical framework for this research.

Problem Statement

Since the federal law (IDEA, 2004) mandated the inclusion of learners with special needs into general education, multiple authors have worked on identifying the most appropriate educational settings for SWD (Cinquin et al., 2019; Dell & Newton, 2014; Farmer et al., 2016; Herold & Chen, 2021; Johnson et al., 2021; Joosten & Cusatis, 2020; Kates et al., 2018; Kent et al., 2018; Lemons et al., 2018; Rossa, 2017). At the same time, the development and implementation of ICT enhanced traditional face-to-face instructions and improved the learning experience of students with and without disabilities (Alaniz et al., 2017; Clark & Mayer, 2016; Erbil, 2020). For instance, traditional face-to-face instructions included such child-centered educational concepts as the Universal Design for Learning (UDL), Augmented Reality (AR), and gamification (CAST, n.d.; Walker et al., 2017).

In addition, multiple research studies have demonstrated that online and blended settings were beneficial for students' academic performance, course satisfaction, and emotional well-being (Cinquin et al., 2019; Dendir, 2019; Erbil, 2020; Kent et al., 2018; Kotera et al., 2019; Lu et al., 2018; Miranda et al., 2017; Mullen, 2020; Sublett & Chang, 2019; Thai et al., 2019). However, some researchers have reported that ICT and multimedia may negatively impact student's learning outcome and emotional status (Baier et al., 2018; Lucky et al., 2019; Wise, 2019). Furthermore, several recent studies found that many SWD demonstrated significant

academic loss and increased anxiety after their mandatory placement in the fully online setting during the COVID-19 pandemic (Halloran et al., 2021; Kulikowski et al., 2022; Sass & Goldring, 2021).

These contradictory results have revealed a noticeable gap in the current body of professional literature highlighting studies with research on the cognitive development of SWD. Cinquin et al. (2019) noted that most studies are concentrated on specific disabilities rather than on students' cognitive functioning. Consequently, the lack of a theoretical foundation for this practical issue may lead to inconsistent findings. In addition, there were calls for research papers in educational response to the global COVID-19 pandemic (Smith et al., 2020). Unfortunately, research that addresses this topic is still insufficient. The problem is that the literature did not fully address the issue of the effectiveness of different educational settings for students with and without disabilities.

Purpose Statement

The purpose of this quantitative, non-experimental causal-comparative study was to determine whether there is a statistically significant difference in the academic performance of high school students with and without disabilities who received math instruction in the face-to-face and online educational settings. The study used the Georgia Milestones End-of-Course test (GA Milestones EOCT) scores in Algebra I of a convenience sample of 588 high school students. These participants attended 9th through 12th grades in two public Title I schools in the rural North Georgia school district. During the 2020-2021 school year, these students took two semesters of Algebra I in different educational settings and participated in the GA Milestones EOCT for Algebra I in the spring of 2021. The present study aimed to investigate whether there

is a statistically significant difference among the groups of students with and without disabilities who had 0, 1, or 2 semesters online.

There were two independent variables, namely, the students' choice of educational setting (the first categorical independent variable) and their disability status (the second independent variable). Lemons et al. (2018) defined an educational setting as a method of delivery and a context in which students receive instructions. A face-to-face setting is an instructional method where a teacher delivers course content in person (Lemons et al., 2018; Wise, 2019). An online educational setting is an instructional modality where students receive all instructions via ICT (Wise, 2019). Disability status is defined as the eligibility of SWD to receive special education services under at least one of the twelve disability categories, which include Autism, Deafblind, Deaf/Hard of Hearing, Emotional and Behavioral Disorder (EBD), Mild Intellectual Disability (MID), Orthopedic Impairment (OI), Other Health Impairment (OHI), Significant Developmental Delay (SDD), Specific Learning Disability (SLD), Speech Language Impairment (SLI), Traumatic Brain Injury (TBI), and/or Visual Impairment and Blindness (IDEA, 2004).

Participants had to choose between online and face-to-face settings for each of the two semesters in the 2020-2021 school year. Therefore, there were three possibilities: (a) 0 semesters in the online setting, (b) 1 semester in the online setting, or (c) 2 semesters in the online setting. The researcher identified students with and without disabilities by marking their disability status with either *yes* or *no*. Consequently, participants formed six groups, depending on their choice of educational setting and their disability status. The dependent variable was the students' scores for the state-mandated Georgia (GA) Milestones End-of-Course Test (EOCT) in Algebra I. This exam reflects the high school students' academic achievements in mathematics. Bandura (2001)

defined academic achievement/performance as the extent to which individuals attained their educational goals. The test scores were discrete (since decimal scores were unavailable) and countable values ranging from 200 to 785.

Significance of the Study

The current study adds to the body of knowledge concerning the effectiveness of an online educational setting in comparison to face-to-face instructions and the role of ICT in special education. In 2019, Wise noted that it is challenging to avoid the use of technologies in all levels of modern education. Furthermore, the movement for full inclusion of SWD has prompted all stakeholders to seek the best research-based educational interventions and technologies (Alaniz et al., 2017; Camacho et al., 2018; Walker et al., 2017). Additionally, due to the COVID-19 pandemic, distance learning has become a vital part of education, including for learners with disabilities (Kulikowski et al., 2022). Multiple researchers have reported various pros and cons as potential outcomes of implementing technologies in classrooms (Camacho et al., 2018; Cinquin et al., 2019; Halloran et al., 2021; Kim & Huynh, 2008; Lucky et al., 2019; Sass & Goldring, 2021; Walker et al., 2017; Waxman et al., 2003; Wise, 2019). Alaniz et al. (2017) emphasized that effective educators, students, parents, and administrators must learn how to leverage the benefits of modern technologies while avoiding their pitfalls.

This study holds significance for all education stakeholders who seek to make evidence-based choices for the most effective and efficient educational setting for all learners. Recommendations for future research studies include examining the factors that can influence students' academic performance in these settings. For example, students' individual disabilities, as well as their severity levels, can impact academic performance in different academic settings. The study's limitations include the population of high school students from two Title I rural

public schools in North Georgia, specific conditions during the assessment, and the weaknesses of a quasi-experimental research design. Future studies may examine different population, location, assessments, and educational settings.

Research Question

RQ: Is there a significant difference in Algebra I skills among high school students based on their disability status and educational setting, taking 0, 1, or 2 semesters online?

Definitions

1. *Academic achievement/ performance*- The extent to which individuals attained their educational goals (Bandura, 2001).
2. *Analysis of variance (ANOVA)* - A procedure that compares multiple groups of independent variables and determines their effect on a continuous dependent variable (Warner, 2013).
3. *Bandura's social learning theory*- A theory of learning that explains acquisition of new behaviors through observation and imitation of others (Bandura, 2001).
4. *Computer-based technologies* (*CBT)*- Specific hardware, software, and micro processing features of a computer or mobile device (MacArthur, 2014).
5. *Educational setting*- A method of delivery and a context in which students receive instructions (Lemons et al., 2018).
6. *Face-to-face educational setting*- An instructional method when a teacher delivers content in person (Lemons et al., 2018; Wise, 2019).
7. *Group ZPD*- A result of the collective scaffolding as a combined effort of all members within a group (Donato, 1994).
8. *Individual Education Program (IEP)*- A document that outlines special education

services for each SWD in the USA public school system (O'Brien & Beattie, 2017).

9. *Information and communication technologies* (*ICT)*- The integration of computers and telecommunication technologies within modern classrooms (Woodward & Ferretti, 2014).
10. *Learning*- A psychological process that occurs during social interactions with a More Knowledgeable Other (MKO). Learning leads to human development and takes place within the child's zone of proximal development (ZPD) through various mediating tools with the MKO's assistance (Vygotsky, 2017).
11. *Least Restrictive Environment (LRE)* – A provision within the Individuals with Disabilities Act (IDEA) that specifies educational settings for SWD, ensuring that these students receive instruction to the greatest extent appropriate alongside their peers without disabilities (IDEA, 2004).
12. *Mathematical Learning Disability*- A broad term that describes various difficulties with learning basic math, including mathematical learning disability, mathematical disability, mathematical difficulty, and developmental dyscalculia (APA, 2013; Ostergren, 2013).
13. *Montessori's child-centered education*- An educational approach that emphasizes principles of independence, observation, following the child's lead, correcting the child, a prepared environment, and the absorbent mind (Montessori, 1973).
14. *More Knowledgeable Other (MKO)*- An instructor who assists learners in acquiring new knowledge and skills. The MKO can be a parent, teacher, peer, or an inanimate source of information (Vygotsky, 1978).
15. *Online educational setting*- An educational model in which students receive academic instructions through integrated ICT (Woodward & Ferretti, 2014; Wise, 2019).

16. *Scaffolding*- The support and assistance provided by the MKO, which adapts to the learner's individual abilities and ZPD (Bernstein, 1961). During scaffolding, the MKO limits and controls the mastery of new skills, providing genuine correction at the lower level and sensory correction at the leading level (Bruner, 1986). Self-regulation is the highest level of scaffolding (Bernstein, 1961).
17. *Special education*- A free, appropriate public education in the least restrictive environment for all eligible students from ages three through their twenty-second birthday. This includes individualized instruction to meet the student's educational needs, preparing them for post-secondary education and/or employment, as well as independent living (IDEA, 2004).
18. *Student with a disability (SWD)*- A student evaluated in accordance with the IDEA and qualified for special education services under at least one of the twelve disability categories. which include Autism, Deafblind, Deaf/Hard of Hearing, Emotional and Behavioral Disorder, Intellectual Disabilities, Orthopedic Impairment, Other Health Impairment, Significant Developmental Delay, Specific Learning Disability, Speech Language Impairment, Traumatic Brain Injury, or Visual Impairment and Blindness (IDEA, 2004).
19. *Vygotsky's sociocultural theory*- A theory that describes the cognitive development of children through social interactions (Vygotsky, 1962; Vygotsky, 1978).
20. *Zone of Proximal Development (ZPD)*- The set of activities that a learner can complete with the MKO's assistance (Vygotsky, 1962).

CHAPTER TWO: LITERATURE REVIEW

Overview

This chapter provides readers with a systematic review of professional literature that investigates the academic performance of students with and without disabilities who receive math instructions in various academic settings. It presents an analysis of peer-reviewed articles, the majority of which report scholarly findings from the past five years. The first section examines Vygotsky's sociocultural theory of cognitive development (1962), which served as the theoretical framework for the recent study. The second section explores recent research studies related to the topic. In conclusion, the researcher summarizes the latest findings and identifies current gaps in professional literature, including a specific gap that supports the necessity for the present study.

Theoretical Framework

The current study aims to compare the academic performance of high school students, with and without disabilities, who received math instruction in face-to-face and online educational settings during the COVID-19 lockdowns. Given the complexity of this topic, it is challenging to identify a single psychological theory that can serve as the theoretical foundation for the study. After considering various theories and their potential combinations, the researcher has selected Vygotsky's sociocultural theory of cognitive development. According to this theory, learning precedes development and requires socially mediated interactions between learners and their instructors (Vygotsky, 1962). The following section provides an overview of the origins of Vygotsky's theory, its evolution, and its contemporary implications.

Origination of the Theory

Lev Vygotsky (1896-1934) was one of the most outstanding multidisciplinary scholars of the twentieth century, who studied psychological and cognitive development in children (Van der Veer, 2021; Yasnitsky, 2018a). During his brief but very bright life, Vygotsky wrote multiple works in various areas, such as art, education, psychology, linguistics, neurology, pedology, and others (Vasileva & Balyasnikova, 2019). Due to his interest in different research fields, many authors compared Vygotsky to Mozart in psychology (Toulmin, 1978; Vasileva & Balyasnikova, 2019). However, the focus of Vygotsky's work was directed towards the formation of the human mind (Daniels & Tse, 2021). Certainly, the social and scientific context of his time constrained research (Van der Veer, 2021). Vygotsky survived World War I, the Russian Socialist Revolution, the Russian Civil War, and political suppressions in the former Union of Soviet Socialist Republic (USSR). He lived in extreme poverty, with a debilitating disability, and died of tuberculosis at the age of 37 (Valsiner, 2021). Despite facing various challenges, Vygotsky summarized his professional experience and formulated the cultural-historical theory of cognitive development, now known as the sociocultural theory. According to this theory, cognitive development occurs through social interactions (Vygotsky, 1962; Vygotsky, 1978). Vygotsky argued that cognitive development is limited to a certain range, depending on an individual's age (Vygotsky, 1962). Vygotsky's analysis of a teacher's role in the learning process is particularly relevant to the present study.

Vygotsky's sociocultural theory of cognitive development underwent multiple revisions and updates (2017). At various times, the theory was known by different names, such as the cultural-historical theory of cognitive development, cultural-historical psychology, and the social interaction theory of cognitive development (Van der Veer, 2021). After Vygotsky's death, his

followers, such as Alexander Luria and Alexey Leontiev, carried on his developmental psychology legacy (Yasnitsky, 2018b). They edited and published Vygotsky's works in the USSR and internationally. Currently, his ideas are popular in the fields of language teaching, mathematics, special education, multimedia education, and others (Newman & Latifi, 2021; Roth, 2017; Roth, 2018; Roth, 2019b; Roth, 2020a; Walshaw, 2017). Van der Veer (2021) suggested that learning about the origin and evolution of Vygotsky's theory can assist modern researchers and practitioners in creating, improving, and implementing the most effective research-based educational practices.

Development of the Theory and Its Principles

The main principles of the sociocultural theory of cognitive development underwent multiple changes and revisions over the ten years of Vygotsky's work (2017). From 1924 until his death, Vygotsky wrote six volumes and hundreds of articles, which reflected the evolution of his ideas about the processes of psychological and cognitive development in humans. His research encompassed various topics, such as the psychology of art, the development of higher mental functions, the philosophy of science, the methodology of psychological research, the relationship between learning and human development, concept formation, the interplay between language and thought development, the phenomenon of play, abnormal human development, and learning disabilities (Vygotsky & Luria, 1930; Vygotsky, 1962; Vygotsky, 1978; Vygotsky, 2017; Vygotsky et al., 2019). Vygotsky's former colleagues and students preserved his works and published the first collection of his writings in 1956 (Van der Veer, 2021; Yasnitsky, 2018a). British publishers released translated versions of his works in the 1930s, in 1962, and in 1978. After the 1980s, Vygotsky's work gained popularity in the USA as an alternative to Piaget's cognitive development theory (Valsiner, 2021; Van der Veer, 2021).

Like any scientific discovery, Vygotsky's novel theory about the development of the human mind heavily relied on the work of his predecessors and contemporaries (Van der Veer, 2021). Among them were philosophers and economists, such as K. Marx and B. Spinoza, physiologists like I. P. Pavlov and V. M. Bechterev, psychoanalysts such as S. Freud and A. Adler, Gestalt psychologists like K. Koffka and M. Wertheimer, pedologists such as P. P. Blonsky and A. B. Zalkind, psychologists like J. Piaget and K. Lewin, and many others (Valsiner, 2021; Van der Veer, 2021; Vasileva & Balyasnikova, 2019; Yasnitsky, 2018a). However, their influence varied, depending on Vygotsky's life stage and circumstances. Many researchers agreed that his academic career can be divided into three periods, namely, the instrumental period, the existential crisis, and the integrative holistic period (Valsiner, 2021; Van der Veer, 2021; Vasileva & Balyasnikova, 2019; Yasnitsky, 2018a).

During each of these periods, Vygotsky's theory underwent significant transformations as a result of changes in his research approaches. Initially, his research adopted an instrumental approach to understanding how humans use objects as mediating aids in memory and reasoning. Then, Vygotsky's research shifted to a developmental approach focused on analyzing how children acquire higher cognitive functions during development. Finally, Vygotsky's research evolved into a cultural-historical approach that investigated how social and cultural patterns of interaction shape cognitive development (Valsiner, 2021; Van der Veer, 2021; Vasileva & Balyasnikova, 2019; Yasnitsky, 2018a). Additionally, Vygotsky's theory had different names at each stage of its development, including cultural-historical psychology, co-constructivism theory, sociocultural perspectives, and the social interaction theory of cognitive development (Valsiner, 2021; Van der Veer, 2021; Vasileva & Balyasnikova, 2019; Yasnitsky, 2018a). After

approximately ten years of refining his theory, Vygotsky formulated its main principles as follows.

Learning via Social Interaction

Vygotsky stated that cognitive development occurs through social interactions with the MKO (i.e., a teacher, a parent, a peer, or even a book or other source of information) (Vygotsky, 1962; Vygotsky, 1978). According to Vygotsky (1962), social interactions give meaning to the surrounding sensory perceptions, guide focus and attention span, and, consequently, lead to cognitive and psychological development. Vygotsky emphasized that humans are social animals living in a dynamic social-cultural network, which varies among human cultures. He suggested that psychology should work on improving these practices if the network offers insufficient opportunities to individuals (Vygotsky, 2017).

Learning and Cognitive Development

To explain the relationship between children's learning and development, Vygotsky (1962) implemented the term zone of proximal development (ZPD). According to his theory, learning always precedes development and occurs within the ZPD with the assistance of the MKO. Vygotsky defined the ZPD as a measure of individual's mental development, or "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem-solving under adult guidance or in collaboration with more capable peers" (Vygotsky, 1978, p.86). He clarified that the ZPD defines the functions involved in the process of maturation. The learner's current ability, and the ability they can achieve with the aid of an instructor identify their ZPD. The lower level of the ZPD corresponds to the child's developmental level, which can be achieved

when working independently. The upper level of ZPD extends beyond actual maturation and developmental levels (Vygotsky, 1978).

The Roles of a Teacher

Over time, the ZPD has become a principal component of developmental psychology and practice, as measures of cognitive development are provided through a perspective on it (Yasnitsky, 2018a). It is important to remember that the ZPDs and the time needed for their acquisition are individual for each student (Vygotsky, 2017). Advancement through and attainment of the upper level of the ZPD depends on the instructional and scaffolding capabilities of the MKO. The MKO is typically assumed to be an older, a more experienced teacher or parent but can also be a learner's peer or someone younger (Valsiner, 2021; Van der Veer, 2021; Vygotsky, 2017; Yasnitsky, 2018a). The highest success in learning occurs when the students become the MKO for their peers (Vygotsky, 2017). Currently, researchers suggest that the MKO may even be a machine, a book, or another source of visual and audio input (Valsiner, 2021; Van der Veer, 202; Vygotsky, 2017; Yasnitsky, 2018a).

Language Acquisition and Cognitive Development

In his book, *Thought and Language* (1962), Vygotsky analyzed the acquisition of first and additional languages and their correlation with cognitive development. Initially focusing on infants and young children, he later extended his research to adolescents and adults (Valsiner, 2021; Yasnitsky, 2018a). Vygotsky argued that language development begins with satisfying physiological needs through self-guiding autonomous speech and culminates in internalized speech as a way of constructing meaning and cognition (Vygotsky, 1962; Vygotsky, 2017). In his works, Vygotsky (2017) often used the metaphor of *a cloud* to describe this process, where *wind* (motivation) moves a *cloud* (thought) until it starts *raining* (speech). Vygotsky (1962)

identified the order of language development as follows: 1. Pre-intellectual speech. 2. Autonomous speech or external speech-thought. 3. Naive psychology. 4. Communicative and egocentric speech (inner speech). He also specified that non-verbal behavior (i.e., pointing gestures and imitations) as well as figurative speech (i.e., hints and allusions) work as language tools for comprehension.

Learning Process

Vygotsky (2017) rejected the ideas of constructivists that development precedes learning. He also disagreed with the behaviorists who argued that learning and development are simultaneous and inseparable. Additionally, Vygotsky debated with Gestalt psychologists who viewed learning and development as two separate but interactive activities (Van der Veer, 2021; Vygotsky, 2017). According to Vygotsky, learning is a psychological process that occurs during social interactions with the MKO (Valsiner, 2021; Vasileva & Balyasnikova, 2019; Vygotsky, 2017). The use of language between the participants in these interactions activates and empowers learner's cognitive potential. For instance, the MKO engages in a cognitive modeling process by speaking aloud while solving a problem. Through repeated step-by-step instructions, students internalize the cognitive tools, making the problem-solving process their own skill (Vygotsky, 2017). In other words, the learner repeats external speech and later internalizes it as individual thought (Vygotsky, 1962). Vygotsky defined internalization as *knowing how,* or the appropriate use of a specific tool. During this process, external speech transitions into a simplified and abbreviated form, namely, thought, which becomes a tool of self-regulation. However, Vygotsky noted that a researcher must externalize the internal processes via speech to investigate an event or a process (Vygotsky, 1962; Vygotsky, 2017).

Learners with Special Needs

After his cross-cultural expedition and clinical practice with children, Vygotsky (2017) concluded that normalized tests do not apply to socio-cultural groups different from the mainstream population. He suggested not judging children based on their differences from mainstream norms, which represent the behavior and mindset of the dominant group. Additionally, Vygotsky warned against characterizing learners with special needs solely based on their handicap. Instead, he recommended using the ZPD for evaluating students to provide teachers with a prospective view of their cognitive development (Vygotsky et al., 2019). Vygotsky argued that the goal of psychology as a science is to address individual weaknesses and help learners reach their full potential. This idea became a cornerstone of correctional psychology for individuals with special needs (Van der Veer, 2021; Valsiner, 2021).

Emotions and Cognitive Development

In the 1930s, Vygotsky studied the ideas of Gestalt, acmeism, and holistic psychologists, seeking to revise his theory of cognitive development (Yasnitsky, 2018a). He also delved into the issue of human emotions and their role in higher psychological functions and development. During this time, Vygotsky embraced Spinoza's idea that emotions should be under the control of intellect (Van der Veer, 2021). He viewed children's play, particularly pretend play, as a perfect opportunity for learners to acquire and practice emotional, cognitive, and moral skills simultaneously. Vygotsky classified role-play as the leading activity for young children, one that facilitates and guides development at a specific stage of life (Vygotsky, 1978). This idea later became a fundamental aspect of the activity theory of child development (Elkonin, 2005; Van der Veer, 2021).

In summary, almost a hundred years ago, Vygotsky formulated the sociocultural theory of cognitive development. At that time, many scholars in Russia supported it. However, like any new concept in science, it faced criticism from some theorists (Valsiner, 2021; Van der Veer, 2021; Yasnitsky, 2018b). Furthermore, other researchers independently studied related topics. The next section presents the works of major theorists who investigated cognitive development and learning processes at the beginning of the twentieth century.

Major Theorists

Vygotsky created his sociocultural theory of cognitive development in the 1920s in Soviet Russia. At that time, the primary goal of the new Soviet educational system was to shape new Soviet citizens with special individual characteristics of *Supermen*, aiming to create a new Soviet nation (Yasnitsky, 2018a). Lev Vygotsky was among the researchers who worked on this task. Initially, the Soviet authorities supported Vygotsky's theory because he attempted to demonstrate that psychological and cognitive development depends greatly on the social environment. During that era, philosophers, politicians, and scholars believed that environmental and societal changes would accordingly alter individual characteristics in response to social demands. Vygotsky's ideas gained popularity in Soviet society and among his colleagues, such as Alexander Luria and the Vygotsky-Luria circle. However, certain researchers and political figures, such as Rubinstein (1937), Leontiev (1937), Ruskin (1937), and Rudneva (1937), criticized Vygotsky's theory, as well as his work in pedology. Eventually, this criticism led to Vygotsky experiencing a professional and personal crisis, and, subsequently, the banishment of his theory and works in 1936 (TSK VKP(b), 1936/1974; Valsiner, 2021; Van der Veer, 2021; Yasnitsky, 2018a).

Vygotsky's Supporters and Followers

Since 1924, when Lev Vygotsky started working at the Moscow Institute of Psychology, he established productive relationships with colleagues and students. In his manuscript, Yasnitsky (2011) described and analyzed Vygotsky's primary academic contacts (or Vygotsky's Circles) at different periods of time. Among them were Kurt Lewin, Alexander Luria, Alexei N. Leontiev, Daniil Elkonin, Leonid Zankov, Alexander Zaporozhets, Bluma Zeigarnik, and many other psychologists, pedologists, neurologists, medical doctors, and defectologists who studied human psychological and cognitive development, building upon Vygotsky's ideas their own independent theories (Dafermos, 2016; Dafermos. 2018; Van der Veer, 2021; Yasnitsky, 2011). Moreover, Alexander Luria and Alexei Leontiev helped Vygotsky to develop his theory. They also facilitated editing, publishing, translation, and promoting it abroad after his death (Yasnitsky, 2011, 2018a). A brief review of their findings relevant to the present study is provided below.

Alexander Luria. Alexander Luria (1902-1997) was one of Vygotsky's closest friends and associates (Yasnitsky, 2011). They met in 1924 and collaborated on several projects in the field of cultural and developmental research. Their famous study (1931-1933) of the cognitive and psychological processes in the Indigenous population during two expeditions to Central Asia provided both researchers with additional data for developing the socio-historical theory of higher mental functions (Glozman, 2018; Luria, 1931; Luria, 1933; Valsiner, 2021; Vygotsky, 2017; Yasnitsky, 2018a). These studies led Vygotsky and Luria to conclude that illiterate people are bound to concrete situations within their reasoning (Luria, 1931; Luria, 1933; Vygotsky & Luria, 1930). It appears that illiterate people had difficulties with abstract reasoning and solving abstract problems that describe situations beyond their practical experience (Luria, 1931; Luria,

1933; Vygotsky & Luria, 1930). Additionally, according to Luria (1933), their perceptual and spatial abilities differed from those of Western people (for instance, they did not have visual illusions). In their works, Vygotsky and Luria confirmed the considerable influence of social life and literacy on human consciousness (Luria, 1931; Luria, 1933; Vygotsky & Luria, 1930).

Glozman (2018) noted that with this research, Vygotsky and Luria became pioneers of cross-cultural studies that further developed after the 1950s. Later, post-Vygotskian researchers demonstrated that various cultural-historical factors (i.e., language, schooling, ecological conditions, and cultural practices) were associated with variations in cognitive processes and abilities in learners. The data from cross-cultural studies in different countries supported Vygotsky's statement that humans change their behaviors and instincts in the process of historical development. Luria (1974) suggested replicating these studies with other populations to examine the differences in their cognitive processes.

Among various fields of scientific interest, Luria established modern neuropsychology (1974). He studied the development of twins, children with and without disabilities, human language and intellect, memory processes and disorders, affects and emotions, human conflicts, as well as impact of brain injuries and neuropathology on higher psychological functions. Luria's research of regulatory functions of language with children with intellectual disabilities was an extension of Vygotsky' theory. Vygotsky' theory also overturned Pavlov's second signal approach that explained human behavior as a result of conditioned reflexes due to positive reinforcement. With that research, Luria rejected a stimulus-reaction correlation, which was one of the founding principles of behaviorism. In 1974, Luria described the working brain as a system composed of three co-active processes, namely, sensory-processing (attention), mnestic-programming (memory and planning), and energetic maintenance systems. Glozman (2018)

noted that the cooperation of Vygotsky and Luria was a turning point in the development of psychological science.

Alexei N. Leontiev. Alexei N. Leontiev (1903-1979) was Vygotsky's student and colleague, who also worked on the socio-historical developmental theory. However, after the split with Vygotsky in 1931, Leontiev created his theory of activity (Leontiev, 2005; Yasnitsky, 2011). According to this theory, activity is the system, a unified process that unites a person and environment (Leontiev, 1978). Activity has a structure, or definite patterns of organization. It also possesses inner transformations, development, and conversions.

Leontiev described learning as a process of internalizing an object by a subject (1977). That is, the object of activity is independent of the subject initially. After active engagement with each other (i.e., process of learning), the subject internalizes the object as its image. The subject-object unity is present in each of the three structural activity units, namely, motive, action, and operation (Leontiev, 1977; Leontiev, 1978). The motive is a leading force that ignites the actions (i.e., hunger leads to the search for food). The actions consist of operations that depend on the environmental conditions (i.e., food is located, acquired, and consumed). The very same actions can become the essential parts of different activities, depending on their purpose and underlying motive. This is a significant difference between the activity theory and behaviorism with its stimulus-response reactivity (Leontiev, 1978).

According to Leontiev (1978), the "mind is a property of living, highly organized material bodies that consists in their ability to reflect through their states the reality around them, which exists independently of them" (p.18). He also defined personality as "a relatively late product of social-historical and ontogenetic development of man" (p. 107). Therefore, a newborn or an infant does not have a personality but only the traits of individuality . For many decades,

activity theory was the leading psychological doctrine in the USSR. Currently, the synthesis of social-historical and activity theories, known as the Cultural-Historical Activity Theory (CH/AT), is one of the most popular frameworks among western scholars (Dafermos, 2016; Dafermos, 2018).

Summary: Alexander Luria and Alexei Leontiev. In the 1920s-1930s, Vygotsky's followers studied human cognitive and psychological development, contributing to his social-historical theory while simultaneously developing their own conceptual systems. Both Luria and Vygotsky pioneered cross-cultural studies that demonstrated the substantial influence of social life and literacy on cognitive development in different populations (Glozman, 2018, Luria, 1931; Luria, 1933; Vygotsky & Luria, 1930). The findings of these studies led Vygotsky to emphasize the inapplicability of standardized tests for non-mainstream learners (Vygotsky, 2017). Luria also investigated the impact of brain injuries and neuropathology on higher psychological functions, as well as the regulatory functions of language on cognitive development in children with disabilities (Luria, 1974). His findings laid the theoretical and methodological foundations for the science of defectology and special education (Yasnitsky, 2011). Another of Vygotsky's students and close collaborators, Alexei Leontiev, advanced the social-historical theory by integrating it with his own activity theory (Leontiev, 1978). Naturally, this integration did not occur immediately. It was accompanied by numerous personal and scientific clashes between the groups of researchers (Leontiev, 1978; Van der Veer, 2021; Yasnitsky, 2011).

Criticism of Vygotsky's Theory in the 1920s

Vygotsky experienced many historical and cultural events that shaped his worldview. In less than twenty years, the wars and revolutions destroyed and then rebuilt the society in which he lived. Consequently, Vygotsky went through several professional and personal crises and

revised his theory multiple times. Additionally, like any new study, his work underwent peer reviews and re-evaluation (Van der Veer, 2021; Valsiner, 2021). The following section reviews some of Vygotsky's ideas that faced criticism during his lifetime.

Abolition of pedology. Pedology was a branch of science that combined psychology, pedagogy, and pediatrics (Sikhova et al., 2020; Vygotsky, 1931). Vygotsky was one of the most active proponents and contributors to pedology in Russia in the 1920s, when the newly formed government worked on creating a new education system to eliminate illiteracy and homelessness. Pedology aimed to diagnose and address the individual educational needs of all learners. However, its' main goal was to create a *new Superman* for the communist society (Sikhova et al., 2020; Yasnitsky, 2011). To achieve this goal, pedologists collaborated with teachers and psychologists to create differentiated instruction for individual learners. Pedologists assessed the learners' intellectual abilities with various standardized tests, such as the Binet-Simon system (Sikhova et al., 2020). During that time, the government transformed schools into the centers of children's lives. According to pedology, teachers were responsible for providing students with knowledge and opportunities for self-development (Sikhova, et al., 2020). Petrovskiy summarized the four main principles of pedology, namely, the *holistic* approach to the study of the child; the genetic principle that included Vygotsky's ZPD; taking into consideration the social context; and evaluation of the child's development to provide psychological assistance (Minkova, 2012; Petrovskiy, 1991; Petrovskiy, 2007; Vygotsky, 1931).

Despite its positive intentions and achievements, pedology experienced major political and methodical conflicts (Minkova, 2012). First, a lack of qualified staff among practitioners led to the overuse or misuse of psychological diagnostics (Sikhova et al., 2020). Consequently, pedologists labeled a disproportional number of students as *retarded* and placed them in

correction classes or held them back (Minkova, 2012; Sikhova et al., 2020). Second, based on the results of intellectual diagnostics, students from higher societal classes (aristocracy and bourgeoisie) obtained higher IQ scores than students from the lower classes (i.e., proletariat and peasants). These results supported Vygotsky's ideas about the importance of the environment for psychological and cognitive development (Vygotsky, 1931). However, this conclusion was criticized by the political authorities of the first country in the world where the previously suppressed proletariat and peasants acquired political power (Rubinstein, 1937; Rudneva, 1937; Ruskin, 1937; Svadkovsky, 1937).

Since 1927, severe criticism from political and scientific leaders initiated the decline of pedology in Russia. In 1936 (less than two years after Vygotsky's death), pedology was labeled as a pseudoscience and a reactionary bourgeois science. Consequently, all professionals in the field of pedology lost their jobs (Minkova, 2012; Sikhova et al., 2020; Van der Veer; 2021). Due to this political decision, Leontiev and Luria had to resign from their positions and flee from Moscow, seeking protection from political suppression (Sikhova et al., 2020; Yasnitsky, 2011). To escape prosecution, Luria acquired a medical degree and became a neuropsychologist. To save his life and career, Leontiev wrote a critical article condemning Vygotsky's work in pedology (Leontiev, 1937; Yasnitsky, 2011). Only after 1939, could these two scholars return to the research and educational positions in Moscow and Leningrad (Yasnitsky, 2011).

After the abolition of pedology, developmental psychology research in the USSR ceased to exist for several decades (Minkova, 2012). Only after 1948, works on child psychology were resumed (Leontiev, 1948; Petrovskiy, 1991). Meanwhile, pedology and developmental psychology continued to be in high demand in Western countries. Eventually, they evolved into various educational and psychological services, including special education (Sikhova et al.,

2020). Some scholars classified these services in modern education as professional activities rather than a branch of science .

Vygotsky's self-criticism and revisions of the theory. Various political, personal, and methodological conflicts that occurred in the 1920s forced Vygotsky to review and revise his theory (Van der Veer, 2021; Yasnitsky, 2018a). Many scholars of Vygotsky described this period as his transformation from an *instrumental* to a *holistic* approach (Van der Veer, 2021). During this time, the influence of neurologists and physiologists on his work weakened, while the ideas of Gestalt psychologists and other holistic scholars gained prominence (Van der Veer, 2021; Yasnitsky, 2018a). In multiple writings, Vygotsky (2017) criticized his own early ideas and the works of his collaborators and colleagues. Several significant critical changes in Vygotsky's theory are listed below.

First, Vygotsky abandoned the separation of *lower* and *higher* psychological functions and began describing them as a unified, mutually correlated function of consciousness (Vygotsky, 2017). Second, Vygotsky acknowledged that he had overemphasized the role of speech/language and underestimated the role of emotions in human psychological development . Next, Vygotsky agreed with some of the ideas in Piaget's theory, particularly the notion that egocentric speech dissolves away with maturation. Finally, Vygotsky rejected reductionist views on signs as tools of consciousness (Van der Veer, 2021; Yasnitsky, 2011; Yasnitsky, 2018b).

External criticism. Vygotsky's deep involvement with pedology, previously supported by authorities, became dangerous by the end of the 1920s, due to changes in the political course of the Soviet Russia (Minkova, 2012; Sikhova et al., 2020; Yasnitsky, 2011). As a result, Vygotsky faced criticism for borrowing his ideas from Western theorists who were hostile to the Soviet republic. Some critiques argued that the theory was impractical and inapplicable during a

time of rapid societal change. The others labeled Vygotsky's theory as a vulgar Marxist interpretation of human psychological processes (Yasnitsky, 2018b; Van der Veer, 2021). In addition to these politically charged allegations, Vygotsky's social-historical theory sparked discussions among researchers studying human development.

One of the most serious challenges came from Vygotsky's former friend Leontiev (Leontiev, 1937; Yasnitsky, 2011). In 1931, Leontiev separated from Vygotsky and started working on his own activity theory in Kharkov, Ukraine. There, Leontiev established a new group of scientists that would become the leading psychological school in the USSR a few decades later. These proponents of activity theory criticized Vygotsky for overestimating the role of speech/language in human development and for his idealistic approach to understanding psychological functions (Leontiev, 1937; Rubinstein, 1937; Van der Veer, 2021). According to Leontiev (1937), human activity in society shapes individual consciousness. Leontiev described the roles of mediation, environment, and teachers differently than Vygotsky. However, after Vygotsky died in 1934, Leontiev maintained that his activity theory was built upon Vygotsky's social-historical theory and logically completed it (Leontiev, 1978). Currently, the cultural-historical activity theory (CH/AT) gained popularity in many countries (Dafermos, 2016; Dafermos, 2018; Van der Veer, 2021).

Summary: Criticism of the theory. Vygotsky created his theory of human development in the 1920s-1930s. These were difficult years when Communist Party leaders controlled the scientists and their work. Criticism from the authorities could lead to political suppressions and criminal charges (Sikhova et al., 2020; Van der Veer, 2021; Yasnitsky, 2018b). As a vivid proponent of pedology, Vygotsky lost the support of the higher-ups after its abolishment (Yasnitsky, 2011). In addition, Vygotsky's colleagues reviewed and sometimes criticized his

works. According to Yasnitsky, the split with Leontiev in 1931 negatively impacted both scholars. Thus, the 1930s became a time of deep personal and professional crises for Vygotsky, during which he rejected his earlier ideas and radically revised the theory.

Advances in Research and the Current Study

Vygotsky's theory of sociocultural development has specific characteristics that dictated its choice for the current research. The most important of them is the position that learning precedes and leads development (Vygotsky, 2017). It is also important to understand the significance of the MKO, the types of mediators, the role of ZPD, and the importance of the educational environment, as well as the learners' self-regulation and their active position in the learning process. Modern theories of multimedia education often utilize these ideas and report encouraging results (Alaniz et al., 2017; Mayer, 2009; Miller et al., 2018; West, 2021). Nevertheless, many scholars continued working with the original sociocultural theory, expanding, and revising it (Dafermos, 2018; Valsiner, 2021; Vasileva & Balyasnikova, 2019). The following section introduces their findings that are related to the current study.

Recent Applications of Vygotsky's Theory

Vygotsky was a deeply interdisciplinary scholar (Valsiner, 2021). His cultural-historical psychology contained ideas and principles that are still relevant and applicable to several modern branches of science that explore human development, neuroscience, culture, psychology, education, language acquisition, defectology, and communication (Vasileva & Balyasnikova, 2019). Nowadays, researchers implement various aspects of Vygotsky's theory, sometimes combining them with other theoretical approaches (Clara, 2017; Dafermos, 2018; Dafermos, 2018; Daniels & Tse, 2021; Hedges, 2021; Kim et al., 2021; Shvarts & Bakker, 2019; Vasileva & Balyasnikova, 2019). The focus of the present study is the academic performance of students

with and without disabilities who received math instructions in different educational settings during the COVID-19 lockdowns in the USA. The next section of this paper will review the related findings of researchers in light of Vygotsky' theory of cultural-historical development.

Vygotsky's theory in modern society. In the 1980s, Piaget's theory of cognitive development lost its popularity among Western educators and psychologists (Tudge & Winterhoff, 1993). The alternative theory, Vygotsky's cultural- historical psychology, rapidly started replacing it (Smolucha & Smolucha, 2021). According to Vygotsky, human development is a result of socially mediated learning (Vygotsky, 1978). Tudge and Winterhoff (1993) compared the theories of Piaget, Vygotsky, and Bandura. They concluded that these three paradigms reflected the prevailing worldviews of their creators based on their cultural-historical backgrounds. Thus, Vygotsky's ideas represented contextualism, in which development is a social process from birth. It occurs with the assistance of the MKO within the child's ZPD through the mediation of various tools (Vygotsky, 2017). Bandura's theory represents a mechanistic approach. It states that a child develops through the imitation of models and observational learning (Bandura, 1986; Tudge & Winterhoff, 1993). Piaget's theory represented an organismic approach. According to Piaget's theory, children learn by working alone and trying to make sense of the world around them (Piaget, 1953; Piaget, 2000). Tudge & Winterhoff (1993) noted that each of these theories has its followers, but overall, they simplify the processes of psychological development. Currently, scholars use these three approaches in different combinations (Clara, 2017; Tudge & Winterhoff, 1993).

The principle of ZPD. Vygotsky maintained that the construct of ZPD can work as an instruction base and as a maturity gauge for psychological functions (Clara, 2017; Vygotsky, 2017). Consequently, since development occurs through learning, the ZPD can be used as an

instrument to measure learning outcomes. The ZPD refers to the potential for a child to reach a higher level of conceptual development, which is only possible within instructional context (Clara, 2017). It becomes evident during interactions with the MKO, whose role is to identify the ZPD and utilize it for instruction and evaluation (Clara, 2017; Vygotsky, 1978). Kim et al. (2021) suggested that boredom and frustration experienced by students can serve as markers for their ZPDs because learners encounter these negative reactions when assignments are either too difficult or too easy. Thus, the ZPD could replace formative and summative assessments that reveal present levels of development (Kim et al., 2021). Unfortunately, there is still insufficient empirical evidence to support the use of the ZPD as an evaluation tool.

Scaffolding. Research has shown that in the successful learning process, the adult's assistance adapts to the child's ability in such a way that the adult offers a great amount of assistance at the start of a process and then this assistance gradually decreases (Clara, 2017; Eun 2019; Shvarts & Bakker, 2019; Smolucha & Smolucha, 2021; Vygotsky, 1978). The term *scaffolding* describes this support from the MKO. Smolucha and Smolucha (2021) noted that Vygotsky and Luria did not frequently use this term in their writings. Instead, it was a common metaphor in the newly reconstructed Soviet republic during the 1920s. Later, Bernstein (1961; 1970) adopted this term to describe motor development, defining scaffolding as temporary adaptive support.

J. Bruner further developed Bernstein's ideas about scaffoldings (Bruner, 1986; Shvarts & Bakker, 2019; Smolucha & Smolucha, 2021). He also appreciated Vygotsky's works and corresponded with Luria. In his own research, Bruner began using the term *scaffolding* to describe the limits and reductions in mastering new skills with genuine correction at the lower level and the sensory correction at the leading level (Bruner, 1986). Along with his colleagues,

Bruner created the scaffolding theory and described the functions of scaffolding, namely, recruitment, reduction in the degree of freedom, direction maintenances, marking critical features, frustration control, and demonstration (Bruner, 1986; Wood et al., 1976). Researchers suggested that scaffolding within ZPD may trigger the developmental process and lead to qualitative change much later, when a skill or concept acquired through teaching/learning would undergo future developmental change.

In his theory, Vygotsky (1978) noted that even though instructions necessarily require contingent social interactions, they do not require participants to share the same space or time physically. For instance, when children work independently, they imitate their teacher who is not standing near them at that moment. This process of interiorization of scaffolding leads to its highest levels, namely self-regulation and self-development (Bernstein, 1961; Bernstein, 1970; Wood et al., 1976). Some scholars have suggested that limited empirical evidence of the self-scaffolding process that follows intersubjective scaffolding in the form of self-regulation creates a gap in the research (Clara, 2017; Shvarts & Bakker, 2019; Smolucha & Smolucha, 2021).

Group ZPD. In the classroom, the scaffolding is collective; therefore, its distribution among students leads to the creation of a group ZPD shared among the participants (Clara, 2017; Daniels & Tse 2021; Donato, 1994; Erbil, 2020; Hedges 2021). Donato (1994) defined the group-level ZPD as a result of a combined effort of all members. Similarly, in the sociocultural theory (Vygotsky, 1978), scaffolding is a result of social interactional guidance. Erbil (2020) used this approach to study the implementation of the cooperative learning method in the flipped classroom. The flipped classroom is one of the variants of blended learning, where the teacher assigns passive transfer of information (e.g., a video) as homework. The process of active learning occurs in the student-centered classroom through social interactions with peers and the

teacher. Active teaching techniques may include various methods that engage students, such as cooperative learning, project-based learning, and problem-based learning. Erbil listed the characteristics of the cooperative learning method, such as positive interdependence, individual accountability, face-to-face interactions, interpersonal and small group skills, and group processing. Techniques, such as discussions, brainstorming, concept mapping, students' presentations, and gaming can be used in the active learning process. Erbil concluded that the flipped classroom and cooperative learning methods are teaching methods that support Vygotsky's approach because they include active learning, active teaching, and an active environment. Erbil noted that there is gap in the research, specifically regarding the peers' influence on individual and group learning performance.

Tools. The tools for cognitive development can be technical (e.g., calculators), symbolic (e.g., language), and social (the MKO) (Eun, 2019). During the teaching/learning process, the MKO leads the development of a less capable person through the use of various symbolic and technical tools (Tudge & Winterhoff, 1993; Vygotsky, 1978). Leontiev (1978) noted that his activity theory continues Vygotsky's interactional view of individuals and their environment with social primacy. He argued that the goal of modern activity theory is to understand the mental capability of the individual. Engestrom (1987) later modernized the activity theory by adding the community as the third participant in the human development process. Current explorations of the effectiveness of ICT and multimedia in education often use Vygotsky's concepts of educational tools and the environment (Alaniz et al., 2017).

Culture and cognitive development. Culture is a human practice of social sharing information with the use of symbols (Vygotsky, 1978). Cultural development utilizes signs as mediators in higher psychological functions (Clara, 2017; Vygotsky, 2017). The law of cultural

development states that any function in cognitive development first appears between people and after that, in the individual's mental plane (Vygotsky, 2017). The ability to create and use symbols develops during language/speech acquisition and pretend play with object substitutions (Smolucha & Smolucha, 2021; Vygotsky, 2017). Modern researchers suggest that play can introduce a child to various educational activities, such as art, science, math, and athletics because it creates the ZPD (Smolucha & Smolucha, 2021). As for language/speech, during cognitive development, self-guiding inner speech transforms elementary mental functions into consciously directed higher mental functions, such as memory, attention, emotions, analytical reasoning, creative imagination, will power, moral reasoning, and self-identity (Clara, 2017; Hedges, 2021; Smolucha & Smolucha, 2021). Both play and language/speech are important tools of cognitive development and learning (Vygotsky, 1978).

Teachers as mediators. Multiple research studies have demonstrated that teachers are the most significant players in the educational process, having the greatest impact on students' learning outcomes (Clara, 2017; Eun, 2019; Hedges, 2021; Smolucha & Smolucha, 2021). According to sociocultural theory, the MKO mediates the use of tools during the process of cognitive development (Eun, 2019, Hedges, 2021; Vygotsky, 1978). Both the teacher and the student work on co-constructing and internalizing knowledge. This process is mutually changing and requires an extensive amount of time for reflection and self-monitoring by all participants. Vygotsky (1978) emphasized the importance of concrete goal-directed activities in the classroom that should be appropriate for each learner's developmental stage. Many scholars have suggested that the teacher's role is to be a coach and an observer (Montessori, 1917; Ratner & Efimova, 2016; Vygotsky 2017). If a teacher does not address the ZPDs and developmental level of learners, these learners may experience frustration and/or boredom (Clara, 2017; Erbil, 2020).

Researchers argued that teachers as mediators should address emotions and intellect of the students to improve learning outcomes. Therefore, learning should be practical, authentic, and relevant to the learners' experience and culture. Mediation allows learners to acquire knowledge and skills using cultural tools and processes (Hedges, 2021).

Levels of communication. Research studies on language games have revealed the social nature of language (Kim et al. 2021; Lantolf & Xi 2019; Vygotsky, 1962). Additionally, studies have demonstrated the importance of non-verbal behavior (e.g., gestures or tone, for example.) in the development of language and meaning (Clara, 2017; Luria, 1933; Vygotsky, 1962). Furthermore, it has been found that social interactions and instructions work simultaneously on two distinct levels, namely, informal (or spontaneous) and formal (or non-spontaneous) (Clara, 2017; Daniels & Tse, 2021; Erbil, 2020; Hedges, 2021; Kervinen et al., 2020; Vygotsky, 1962). Hedges (2021) noted that informal learning (i.e., in families) is often undervalued. Hedges compared formal learning to the assembly of instructions, whereas informal (or spontaneous) learning is an interactive component in meaningful activities with intentional participation. During informal learning, the MKO provides immediate guidance through social interaction and situations of activities. Additionally, talk during informal learning is conversational and didactic. It is important that learners' involvement builds on individual traits and abilities, while assessment occurs in a supportive environment and contributes more to the activity than to external purposes. Moreover, all participants have a chance to apply their existing knowledge, skills, and ideas during this informal communication.

Instructions. Both spontaneous and non-spontaneous education play important roles in cognitive development (Clara, 2017; Hedges, 2021; Vygotsky, 1978). During spontaneous learning, students form the meanings on their own. However, some meanings can only be formed

within and after instructions (Clara, 2017; Vygotsky, 1978). Instructions are a type of a child-adult collaboration, which includes intellectual or meaningful imitation (Vygotsky, 1978). Clara (2017) suggested calling this type of instructions *intellectual imitation*, which clearly differs from *inquiry-based instructions*. In the latter, the adult's function is not to form a meaning but rather to arrange the environment, conditions, and conversations in ways that permit the child to form the meaning independently. Non-spontaneous meaning is a result of intellectual imitation. On the contrary, spontaneous meaning forms during instructions, but it has little significance for the child's conceptual development. (Clara, 2017; Vygotsky, 1978).

Importance of self-development. Sikhova et al. (2020) described school as a place where a child develops moral values, autonomous personality, and self-regulation. That is why one of the teacher's roles is to facilitate students' self-development. Self-development is a result of self-regulated learning and the highest level of cognitive development (Clara, 2017; Vygotsky, 2017). One unit of self-development is the structural connection between spontaneous and non-spontaneous meanings (Clara, 2017). Vygotsky (2017) discovered the law of interconnections between higher and lower systems in psychological development. That is, the development of non-spontaneous concepts begins in the domain of concrete and empirical knowledge. Non-spontaneous concepts move toward the higher characteristics of concepts (or non-spontaneous meanings) in the domain of conscious awareness and is based on instructions. Kervinen et al. (2020) suggested that there are three places for knowledge acquisition and self-development, namely the home culture, the school culture, and the intersection between them, where meaningful dialogue between a teacher and students happens.

Institutional modality of specialized settings. British sociologist B. Bernstein, who worked in the sociology of education and cultural transmission, explored the issues of control

and regulation of mediation in the works of Vygotsky (Bernstein, 1961). Bernstein's theories and practices facilitated development and learning in socially disadvantaged groups of learners, as well as in students with severe and profound learning disabilities (Bernstein, 1961; Daniels & Tse, 2021). Bernstein studied speech as a tool that mediates thinking and feeling. He also investigated different modalities of institutions and speech-based instructions with these modalities. Additionally, Bernstein examined how institutional relations of power and control translate into principles of communication and regulate forms of consciousness. He noted that different institutional modalities may be described in terms of the relationships between power and control. However, modality does not imply homogeneity in learners or their academic outcomes.

Finally, Bernstein (1970) argued that institutions may maintain some cultural forms more frequently than others, thus modifying and typifying the culture of institutions. Bernstein emphasized that neither institutions nor their cultural products determine the social mind. However, they shape the possibilities and likelihoods of influencing the minds. Research has shown that tightly structured and controlled institutions reveal fewer variations in outcomes than those with weak relations of control (Bernstein, 1970; Daniels & Tse, 2021). According to Bernstein (1970), the relatively strong control of students' learning facilitates maintaining order in the context of learning. On the other hand, strictly framed social relationships between teachers and students have more asymmetric hierarchy. With fewer restrictions, children will be motivated to be active in class while having symmetric relationships with their teachers and peers (Bernstein, 1970; Daniels & Tse, 2021).

Environment and cultural neuroscience. Vygotsky (2017) defined culture as an environment of signs and language. According to his theory, children are not only a part of a

human-created environment but also a product of a linguistically mediated environment that becomes internalized during development (Vygotsky, 1962). Multiple research studies have demonstrated that interactions with tools and the environment change the learner's brain and its functions (Clara, 2017; Hedges, 2021; Luria, 1976; Vygotsky, 2017). This phenomenon is the focus of cultural neuroscience (Luria, 1976). Vasileva and Balyasnikova (2019) noted that a child's interaction with language, cultural tools, artifacts, and the social environment may lead to changes in the brain, thus developing new functional systems. It is important to remember that the same environment impacts people differently depending on their developmental stage (Eun 2019; Vygotsky, 2017). Therefore, a teacher's responsibility is not just to simplify the decontextualized knowledge but to sustain productive interaction between learners and their environment (Eun, 2019; Luria, 1976; Vygotsky, 2017).

Principles of Early Childhood Education. Education in the Western countries traditionally used an approach where development leads to learning (Hedges, 2021). After the 1980s, when Vygotsky's and post-Vygotskian works became popular, this paradigm changed to the opposite one, where learning precedes development (Hedges, 2021; Vygotsky, 1978). Based on this idea, the Early Childhood Education (ECE) principles evolved into the following: 1. ECE is largely informal, rich with possibility, and promoted through authentic collaborative community participation. 2. While intentional and purposeful, it can appear disorganized because it is fluid and dynamic. 3. Children have limited life experience, but their thinking, inquiry, and imagination have internal logic. 4. Effort to learn reflects children's interests and a wish to participate and achieve. 5. Adults empower learning when they know children, their interests, and families. 6. Early learning gives the opportunity to recreate acquired knowledge and

experience in play. 7. Holistic learning includes intellect, affect and imagination in the knowledge, skills, and disposition (Hedges, 2021).

Wells (1999) extended Vygotsky's ideas about using authentic learning situations to foster children's language and knowledge development. He stated that teacher's responsibilities are not necessarily to guide children's learning towards accurate conceptual knowledge development but to galvanize their personal and collective learning trajectories. The process of learning includes observation, participation, inquiry, and meaning making, which are involved in formal learning, as well as inquiry-based activities. The goal of schooling is to support children's curiosity and facilitate collective learning with their teachers and peers. This approach ensures that children develop positive learning dispositions that culminate in developing an identity as a capable learner (Hedges, 2021; Wells, 1999). The lack of learning skills and capabilities may lead to developmental delays and various learning difficulties in children (Luria, 1933; Vygotsky, 2017; Wells, 1999).

Cognitive development in students with learning disabilities. Learning disabilities (LD) are an interdisciplinary phenomenon that combines neuroscience and developmental psychology (Luria, 1976; Vasileva & Balyasnikova, 2019). During a child's development, the brain reorganizes neuronal connections. However, neurons do not mature by themselves. The communication and internal activities of a child form the neurons (Luria, 1974). That is why the brain is both a biological and a cultural organ (Luria, 1974; Toomela, 2014). The hierarchical nature of functional systems allows for a fresh perspective on understanding impairments in brain damage and developmental disorders. The brain's compensatory mechanisms might differ depending on the age at which the damage occurred (Luria, 1976; Vasileva & Balyasnikova, 2019). Different brain processes may produce similar symptoms (Luria, 1974).

Research has demonstrated that there is a link between the emergence of LD and cerebral immaturity related to cognitive development (Luria, 1974; Ratner & Efimova, 2016). Researchers have reported that students with learning disabilities (LD) often cannot work with abstract concepts (Kim et al., 2021; Ratner & Efimova, 2016). In such cases, returning to concrete concepts, real-life situations, and practical applications of the concept may benefit the students (Montessori, 1917; Montessori, 1973; Ratner & Efimova, 2016). Positive encouragement and constructive feedback may improve students' motivation to learn and their self-control (Bandura, 1977; Montessori, 1973). It is also important to take into consideration a student's ZPD for instructions and evaluation (Kim et al., 2021). On multiple occasions, Vygotsky (2017) emphasized that the evaluation of learners does not include their comparison with mainstream norms. He argued that the general child does not exist and extrapolating norms that hold in one subculture to others leads to misguided judgements and injustice (Vygotsky & Luria, 1930; Vygotsky, 2017).

LD is a multidimensional issue that is a consequence of a complex of endogenous and exogenous factors. LD may lead to a decline in the quality of a learner' life (Ratner & Efimova, 2016). Many researchers see the cause of LD not in the lack of certain knowledge or physiological brain functions but in the lack of the learner's executive functions. Executive functioning disorder may explain the causes of LD of students who do not have evident deviations in their intellectual or physical development. Their characteristics include underdeveloped universal learning abilities in the personal, regulatory, cognitive, and communication areas. The most common examples of this disorder are the inability to get to work without delays, to plan work stages, to select and organize materials for work, to complete assignments on time, and to properly self-evaluate. It is important for the teacher to use

scaffolding, that is, a temporary adaptive support and promote the learner's self-development and self-regulation (Bruner, 1986; Shvarts & Bakker, 2019; Wood et al. 1976).

In his theory, Vygotsky (2017) maintained that intellect and affect are interrelated. Positive or negative emotions can impact the learner's ZPD and motivation. The role of mediation is to help children make sense and meaning from the world, including relations with other people. Children acquire multimodal ways to interact with others and internalize their knowledge during imaginative and symbolic play using speech/language as the main cultural tool (Vygotsky, 1978). Smolucha and Smolucha (2021) found that over-controlling, overly critical, or verbally abusive social of family interactions may cause long-term neurological damage resulting in a child's LD. This damage requires psychotherapy for *rewriting* maladaptive self-talk under the guidance of an empowering role model.

Mathematical education. Vygotsky's work provided researchers with theoretical tools for interpreting the social origins of thinking and learning in different areas, including math education (Roth, 2017; Walshaw, 2017). Vygotsky maintained that learners' interactions with others' talk and actions, as well as their interactions with symbols and tools within the classroom environment, mediate their development (Vygotsky, 2017; Walshaw, 2017). During everyday joint activity, the MKO provides a scaffold to support the child's developing understanding. When the new understanding is sustained, the MKO removes this scaffold, allowing the child to act independently. Developing shared understanding is an ongoing responsibility of the teacher who must ensure interaction and engagement with students, as well as commitment from them (Ng, 2021; Roth, 2017; Seleznyov et al., 2021; Vygotsky, 1978; Walshaw, 2017). Walshaw (2017) analyzed mathematical development through Vygotsky's theory. He stated that Vygotsky

conceptualized mathematical development as a process that involves participation, communication, inclusiveness, inter-activeness, and collaboration.

Thinking and reasoning emerge through practical activities in the social environment and in relation to the cultural, historical, and material reality of the activity (Vygotsky, 1978). Walshaw (2017) noted that students are not just mirroring their classroom environment. Instead of being passive and acted upon, students actively construct knowledge through social and societal interactions. The individual and the environment are mutually constructive because cognition develops in and for the purpose of action. The effectiveness of an activity in developing mathematical thinking depends on the strength of the connection that a teacher makes between students' motivation, knowledge, competencies, and the curriculum-based goals of the activity. Teachers tend to use specific linguistic strategies to strengthen this connection, allowing students to enhance their existing knowledge and consolidate the new knowledge as a shared understanding (Ng, 2021). Teachers use tools for guiding, monitoring, and assessing the activities. They also use language as a tool for describing and consolidating shared experience and understanding within the class (Walshaw, 2017).

Vygotsky (1978) maintained that humans control their activity using tools and signs, which stimulate the brain in certain ways. However, according to Roth (2017), Vygotsky failed to recognize the unity of physical and psychological. For instance, speech has both parts, that is, body and mind (physiology and psychology). In *perezhivanie*, or experiencing mathematics, mind and body represent the inner and outer sides of knowledge (Roth, 2017; Ng, 2021). Consequently, there is a double relation: (a) between thinking and body and (b) between thinking and thinking. Roth (2017) argued that the individual does not construct thoughts because they occur automatically. Consequently, learners perceive this process as thinking. Roth maintained

that it is important to realize that we know math if we can do it. He noted that the statement that someone possesses knowledge but is unable to apply that knowledge is absurd.

Roth (2017) argued that mathematics is not socially constructed and the social characteristics in math are incidental. Individuals make mathematical discoveries or prove special theorems before sharing them with society. Thus, individual constructions become social. Roth argued that this is a contradiction to Vygotsky's thoughts that any higher psychological function appeared first in communication with another person. Roth stated that children learn mathematics and mathematical forms because they exist in society. Mathematics becomes individual when a child becomes conscious of the relation with the MKO. Demonstration of the steps while completing the math assignment reveals the thinking process in mathematics.

Students' knowledge derives from a teacher, while teachers' thoughts and actions undergo a transformation after interactions with students (Ng, 2021; Vygotsky, 1978; Walshaw, 2017). The development of shared understanding is a joint activity between teachers and students, as well as their mutual achievement. If the teacher's talk fails to keep the students' minds attuned, scaffolding loses its impact and development of shared knowledge is minimal (Walshaw, 2017). The challenge in the assignment has a potentially leading role in moving students from their actual developmental level (i.e., independent problem-solving) to their higher level of potential development (i.e., problem-solving under adult guidance or in collaboration with more capable peers) (Vygotsky, 1978; Walshaw, 2017).

Walshaw (2017) maintained that Vygotsky's work is the best-known but the least understood theory in mathematical education. In the dialectical (traditional) view, simple cognitive terms cannot explain a construct of mathematical thinking. Like all other developments, it emerges from societal relations and activity. Classroom activity is a complex

interrelated unit in which social, cultural, historical, cognitive elements come into play. Mathematical thinking is not just an inner process but a result of mutually reinforcing societal activity in formal mathematical situations (Roth, 2019a; Roth, 2020c; Walshaw, 2017).

Vygotsky's Modern Criticism

Scholars and practitioners often use Vygotsky's multidisciplinary theory as a theoretical framework for studies in developmental psychology, secondary and post-secondary education, teaching methods, math education, sociocultural perspectives, and child development (Dafermos, 2018; Newman, 2018; Lantolf & Xi, 2019; Roth, 2020d). Nevertheless, Newman (2018) challenged the commonly accepted view that Vygotsky's work is unproblematic. He identified several critical points, namely, confusion with definitions, inapplicability in some cases, and the lack of empirical studies that support the theory (Newman, 2018; Newman & Latifi, 2020). Lantolf and Xi (2019) responded to this critique. First, Lantolf and Xi admitted that there is historical and cultural confusion with definitions. They argued that it is difficult to apply Vygotsky's theory without understanding his historical-cultural background and theoretical positions. His works underwent censorship, banishment, partial publishing, or improper editing (Lantolf & Xi, 2019; Van der Veer, 2021; Yasnitsky, 2018b). Vygotsky died a month before standing trial for *committing a political error*, that is, politically incorrect thinking that could lead to his imprisoning or capital punishment (Pass, 2004; Smolucha & Smolucha, 2021). After Vygotsky's death, his followers and colleagues had to alter his writings to make them more appropriate for the current political situation in the country (Lantolf & Xi, 2019; Van der Veer, 2021; Yasnitsky, 2018a; Yasnitsky, 2018b).

Another factor that added confusion to understanding Vygotsky's writing was the issue of translation from Russian to other languages (Lantolf & Xi, 2019; Smolucha & Smolucha, 2021;

Van der Veer, 2021). Multiple terms in Vygotsky's works do not have a precise match in English. For instance, the Russian word *obuchenie* means either *teaching* or *learning* depending on the context, but sometimes these two meanings may combine. Among other difficult terms were *myshlenie* (i.e., *thinking/thought process/mind*), *perezhivanie* (i.e., *feeling/life experience*), *rech* (i.e., *speech/language*) and others. Many of translations of Vygotsky's works did not consider these interpretations. Consequently, understanding of his ideas was incomplete. Currently, Vygotsky's followers witness the archival revolution that involves the re-discovery, re-translation, and re-editing of his works in different languages (Valsiner, 2021; Van der Veer, 2021; Yasnitsky, 2018a).

Various applications of Vygotsky's theory have emerged in various locations and sociocultural settings, including North America, Latin America, Brazil, China, and Singapore (Newman, 2018; Roth, 2018). During this wave of adaptation, psychologists simplified Vygotsky's ideas and adjusted them to their own systems (Dafermos, 2016; Dafermos, 2018; Lantolf & Xi, 2019). Dafermos (2016) noted that sometimes opposite paradigms utilize Vygotsky's theories to support their ideas (i.e., constructivism, cultural-historical activity theory, and culturalism). Even the name of Vygotsky's theory has changed from the cultural-historical theory (as he named it) to the sociocultural theory (as his followers from the North America renamed it) (Dafermos, 2016; Lantolf & Xi, 2019). The latter embedded the theories of many modern scholars. In summary, theorists transformed original Vygotsky's ideas and then criticized him for these transformations (Dafermos, 2016; Lantolf & Xi, 2019; Smolucha & Smolucha, 2021; Van der Veer, 2021).

Newman (2018) questioned the applicability of Vygotsky's theory. He argued that this theory can explain only the first language acquisition but not the second and additional

languages. Additionally, he stated that inner speech is an abbreviated and simplified external speech rather than internalized concepts that transform into thoughts. Newman (2018) asserted that the sociocultural theory, in fact, is individualistic because internalized social concepts transform into the personal knowledge of an individual. Lantolf and Xi (2019) responded to that argument by noting that a child develops as a social product with a function of socializing. Lantolf and Xi added that, according to Vygotsky, humans can externalize complex internal processes to investigate them, producing written speech as an advanced tool for communication. According to Vygotsky (2017), teachers can use learners' writing as evidence of acquired knowledge.

Furthermore, Lantolf and Xi (2019) disagreed with Newman and Latifi (2021), who stated that Vygotsky did not conduct sufficient empirical research to support his theory. The six volumes of Vygotsky's writings revealed his extensive work with children with and without disabilities (Lantolf & Xi, 2019; Vygotsky, 2017). However, during his last period of life, Vygotsky concentrated on developing new theoretical ideas and creating research plans for his students and followers. These ideas, indeed, needed further investigations. Among the suggested topics were cooperative learning, peer interactions during learning, and the role of peers as the MKOs (Erbil, 2020; Hedges, 2021). Sociologists (Bernstein, 1961; Daniels &Tse, 2020) maintained that there are some limitations to Vygotsky's socio-genetic arguments, particularly the role of social institutions in cognitive development and academic success. Researchers also noted that additional studies are needed to investigate school design and other factors that affect academic performance (Erbil, 2020; Hedges, 2021; Smolucha & Smolucha, 2021).

Dafermos recommended that future research should concentrate on developing Vygotsky's theory and methodology from the perspective of problems arising in psychological,

educational, and social practices around the globe (Dafermos, 2016; Dafermos, 2018). Despite its almost hundred-year-old history, the sociocultural theory is still a working instrument for explaining and predicting various phenomena in psychology, sociology, and education (Dafermos, 2016; Valsiner, 2021; Van der Veer, 2021). That is why the researcher chose it as a framework for the present study. The following section presents the specific research focus.

Specific Research Focus

The purpose of the present study is to determine if there is a statistically significant difference in the academic achievements of high school students with and without disabilities who received math instruction in the face-to-face and online educational settings. Several topics need to be examined to answer the research question. These topics include educational technologies and academic settings, math education in different academic settings, SWD in different academic settings, and academic performance of students during the COVID-19 lockdowns. After a detailed analysis of Vygotsky's theory, the works of his followers, and the constructive criticism from his opponents, the researcher chose the sociocultural theory of cognitive development as the theoretical framework of the present study.

The main reason for this choice was the interdisciplinary character of the theory. It obviously relates to each of the research topics and explains (at least partially) many observed phenomena. Indeed, math education, cognitive development in SWD, the role of tools/learning environment, and teachers as mediators were the research foci of Vygotsky and his followers. Naturally, Vygotsky did not consider multimedia tools and online educational settings in his theory due to the absence of such during his lifetime. However, post-Vygotskian scholars investigated these issues in detail.

Bruner (1986), Shvarts and Bakker (2021), Smolucha and Smolucha (2021, and Roth (2017) agreed that learning outcomes may depend on the scaffolding skills of the MKO. Researchers supported Vygotsky's idea that the MKO mediates the use of various tools (including speech/language) for forming meanings and internalizing the learner's knowledge (Eun, 2019; Hedges, 2021; Roth, 2017; Vygotsky, 1978). In addition, Roth (2017), Walshaw (2017), and Ng (2021) emphasized the role of the teacher's non-spontaneous instructions in mathematics, as this subject is not socially but rather individually constructed with its specific language and methods of acquisition. Roth (2017) maintained that it is impossible to know mathematics without learning to solve math problems. That is why the role of the MKO, who demonstrates the steps of the solutions, is crucial.

Erbil (2020) argued that students' communication with the MKO is limited by the modality of their educational setting (namely, face-to-face, online, or blended). Regardless of the setting, the MKO should take into consideration the learners' ZPD, their abilities, emotional status (i.e., frustration and boredom), interests, and motivation (Clara, 2017; Eun, 2019; Hedges, 2021; Kim et al., 2021; Vygotsky, 2017). Researchers reported that students' level of self-regulation facilitates their independent work with various sources of information that serve as the unanimated MKO (Clara, 2017; Sikhova et al., 2021). However, studies demonstrated that students with LD often lack the self-regulation skills and other executive brain functions that would allow them to be successful in the online educational setting without the teacher's support (Kim et al., 2021; Ratner & Efimova, 2016; Shvarts & Bakker, 2019).

The second reason for the choice of sociocultural theory was the historical-cultural parallel between the past and contemporary social and political events. Vygotsky created and developed his theory during the challenging times of wars, revolutions, and capital

reconstruction of society. This cultural-historical background is somewhat similar to the present-day situation in various parts of the world. For instance, the famine and deadly diseases' effects on the population during the first decades of the twentieth century can be compared with the COVID-19 pandemic and its impact on our modern society. The present study attempts to advance sociocultural theory by adding new findings to the existing knowledge and possibly filling in the gaps. The next section analyzes professional literature related to the research topic.

Related Literature

The present study aimed to examine the academic performance of students with and without disabilities who received math instruction in face-to-face and online educational settings. To analyze the related peer-reviewed publications and seminal works, the researcher divided this multidisciplinary problem into five subtopics, which include (a) educational technologies; (b) types of academic settings; (c) forced e-learning during the COVID-19 lockdowns; (d) academic performance of SWD in different academic settings, and (e) math education in different settings. The next section reviews the knowledge that currently exists in professional literature about each of the subtopics, its links to the proposed study, some of the discovered gaps, and practical implementations of these findings.

Educational Technologies

Alaniz et al. (2017) defined educational technologies as digital tools that facilitate learning. In modern society, various educational technologies often play the role of the MKO because they possess the multifunctional characteristics of an instructor, a tool, and an environment. That is why researchers continue studying the effectiveness of educational technologies and the side-effects from their applications. This section opens with a historical overview of educational technologies. A brief review of possible applications of educational

technologies, establishing their role in classrooms. The latest findings of educational effectiveness conclude the section.

Historical Overview

Dell and Newton (2014) described the 1970s as the time when computers in education worked as assistive technologies. Since then, computer-based technologies (CBT) have been providing learners with and without disabilities with support for reading, writing, and mathematical calculations. MacArthur (2014) defined CBT as specific hardware, software, and micro-processing features of a computer or mobile device. Later, in the 1980s-1990s, the United States (U.S.) Department of Education provided researchers with multiple grants in educational technologies (Woodward & Ferretti, 2014). At the same time, the rapid computerization of society led to the exponential growth of online services and utilities. As a result, CBT evolved into a significant part of the educational environment.

However, these instructions became less popular after the internet became widely available. Instead, they were used sporadically for information search and communications (Woodward & Ferretti, 2014). Consequently, CBT had transformed into information and communication technologies (ICT) (Waxman et al., 2003; Woodward & Ferretti, 2014). Additionally, mobile applications and educational games have become multifunctional. Woodward and Ferretti (2014) defined ICT as the integration of computers and telecommunication technologies in modern classrooms. Both students and educators greatly appreciated CBT and ICT for their positive educational and motivational influence (Alaniz et al., 2017; Standen & Brown, 2014; Waxman et al., 2003). Nowadays, simple assistive technologies have developed into multimedia instructions that help students acquire knowledge in all

academic areas and practice skills that are important for survival in modern computerized society (Alaniz et al., 2017; Clark & Mayer, 2016; Waxman et al. 2003).

Applications of Educational Technologies

Educators and students use multimedia and ICT instructions for differentiating, scaffolding, reading support, writing, and content instructions. Learners also apply educational technologies to access the internet and communicate with other people. In 2014, Dell and Newton predicted that implementations of technologies will evolve into *cloud computing*, the use of mobile devices, speech recognition, and enhanced touch and gestures technologies. It is important that while using these technologies, students can control their pace and the order of assignments, utilize accessibility tools, scaffold the content, and use their accommodations without extraneous help (Miranda et al., 2017). Miranda et al. compared this freedom of choice during the learning process with the free choice of activities in Montessori's child-centered classrooms that were beneficial for children's academic and behavioral development (Gunderman, 2020; Lillard & Taggart, 2019).

Multiple research studies have demonstrated that students experience less stress during online assessments than traditional paper-pencil tests (Kim & Huynh, 2008; Wise, 2019). In addition, students can independently practice various life and behavioral skills during computer simulations and educational games (Standen & Brown, 2014; Walker, 2017). Standen and Brown (2014) found that mobile games may be beneficial for SWD. Walker et al. (2017) reported that implementing CBT, especially AR elements, was a highly effective and efficient way to include SWD in the general education setting. MacArthur (2014) reported that computer-based interventions were effective in developing students' literacy, writing, and calculation skills.

Finally, technologies for education are relatively inexpensive, and many school districts received significant funding for that purpose (Wise, 2019).

Despite the benefits of implementing digital multimedia, researchers reported the pitfalls and drawbacks (Alaniz, et al., 2017; Baier et al., 2018; Camacho et al., 2018; Waxman et al., 2003; Wise, 2019). Wise (2019) warned educators about the possibility of students' disengagement, cheating, and cognitive overload. He also reported that students may develop an increased level of testing anxiety during digital-based learning. Another acute problem in public schools is cyberbullying, which involves deliberate online activities intended to harm others (Camacho et al., 2018). Cyberbullying often negatively affects students' academic performance and overall perception of well-being. Additionally, it can impact teenagers' mental and physical health (Baier et al., 2018). To use technologies in the classroom properly and efficiently, teachers and school administration should receive extensive and continuous training (Alaniz et al., 2017; Camacho et al., 2018).

Effectiveness of Educational Technologies

Currently, thousands of websites and applications present educational content created for users on both Microsoft and Apple platforms. However, assessing the effectiveness of multimedia tools can be quite challenging for educators (Alaniz et al., 2017; Clark & Mayer, 2016). Multiple research studies (Alaniz et al., 2017; Lee & Owens, 2014; Liu et al., 2018; Schroeder & Cenkci, 2018; Seraji et al., 2020) demonstrated that finding or creating a visually appealing presentation is not enough for an efficient lesson. According to the cognitive theory of multimedia learning, the main goal of any multimedia lesson is improving learning outcome by reducing the extrinsic cognitive load (Mayer, 2009; Moreno & Mayer, 2007; Sweller et al.,

2011). To achieve this goal, multimedia designers apply specific techniques (i.e., multimedia principles) to their products.

While assessing educational technologies, educators should consider the effectiveness of various types of presentations. For instance, Molnar (2017) investigated learners' perception of video quality in seven distinct types of multimedia presentations adapted to screens of varied sizes. The researcher noted that this is a significant topic for a modern classroom because students often access online content with their mobile devices rather than with a desktop or a laptop. Molnar also examined how different content categories affect learning outcomes. For that, the researcher compared the slideshow, screencast, presentation, lab demonstrations, interview, documentary, and animation. The results demonstrated that learners can effectively acquire knowledge regardless of the presentation type. However, the screen size affected the perception of multimedia quality. The findings demonstrated that the greatest negative correlation lies between the small screen size and slideshows. The effectiveness of animations, lab demonstrations, and interviews changed the least. Molnar suggested that these findings have significant practical implications. Apparently, multimedia designers and users can safely decrease resolution for some types of presentations but should avoid doing so for others. In summary, the assessment of multimedia involves the evaluation of the multimedia principles, review of the measurements, consideration of the content category, and the choice of technology for presentation (Alaniz et al., 2017; Lee & Owens, 2014; Liu et al., 2018; Molnar, 2017; Schroeder & Cenkci, 2018; Seraji et al., 2020).

Modern research studies investigated the effectiveness of ICT. For instance, Korbach et al. (2017) tested participants in a computer lab with special equipment for eye tracking. Morris and Lambe (2017) provided their experimental groups with iPads, while their control groups

received the lesson via face-to-face lectures via PowerPoint presentations. Kennedy et al. (2016) provided the control group with a lecture with a slideshow, while the experimental group accessed their instructional videos with personal laptops in the computer lab. At the same time, Molnar (2017) investigated learners' perception of the video quality on the large and small screens of mobile devices. Finally, Demir (2018) demonstrated that Facebook can be used for online peer assessment. All these studies established the effectiveness of educational technologies. Even though the findings demonstrated that different multimedia forms have their own requirements, benefits, and limitations, many students exhibited improved learning outcomes (Demir, 2018; Liu et al., 2018; Schroeder & Cenkci, 2018; Seraji et al., 2020). Students also reported decreased cognitive load while using multimedia content aligned with multimedia learning principles (Mayer, 2009; Moreno & Mayer, 2007; Sweller et al., 2011). These conclusions can help instructors to find, assess, and use the latest evidence-based practices that fit their students.

Summary

In less than six decades, educational technologies have evolved from simple assistive tools to complex multimedia instructions that utilize various ICT, including computers, mobile devices, and the internet platforms loaded with educational and gaming software (Alaniz et al., 2017; Standen & Brown, 2014; Woodward & Ferretti, 2014). Through ICT, learners with diverse needs and abilities can access educational content, overcoming limitations, such as health, income, location, and difficult life circumstances (Miranda et al., 2017; Standen & Brown, 2014; Walker et al., 2017). Numerous research studies have explored the effectiveness of various educational technologies for various groups of learners (Alaniz et al., 2017; Clark & Mayer, 2016; Korbach et al., 2017; Morris & Lambe, 2017; Lee & Owens, 2014; Molnar, 2017;

Waxman et al., 2003). Nevertheless, some researchers have reported contradictory findings. For example, MacArthur (2014), Standen and Brown (2014), Walker et al. (2017), and Wise (2019) found that ICT may be beneficial for cognitive and emotional development of students with and without disabilities. On the other hand, Baier et al. (2018), Camacho et al. (2018), and Wise (2019) reported negative side-effects of technologies, such as increased students' disengagement, cheating, testing anxiety, and decreased academic achievements. Further investigation is needed, particularly in academic settings that employ various combinations of ICT.

Types of Academic Settings

An educational setting is a method of delivery and context in which students receive instructions (Lemons et al., 2018). Currently, there are at least three types of academic settings based on the delivery modality of academic content (Thai et al., 2019). That is, face-to-face instructions, online setting, and blended learning. These delivery methods are widely used in modern education worldwide. The following section reviews these three types of settings and discusses their effectiveness for diverse groups of learners. The section also considers the applicability of various delivery methods.

Face-to-Face Instructions

Lemons et al. (2018) and Wise (2019) defined a face-to-face educational setting as an instructional method in which a teacher delivers content in person. This is a traditional setting that has been the only method of teaching for thousands of years. Most of the pedagogical research that exists nowadays investigated multiple forms and techniques of this delivery method. Proponents of in-person instruction insist that it is the most effective setting for young children and for SWD who lack self-regulation skills (Kim et al., 2021; Ratner & Efimova, 2016; Shvarts & Bakker, 2019). In a traditional classroom, the teacher (MKO) mediates the use of tools

(including speech), organizes scaffolding for academic concepts, modifies instructions accordingly to an individual learner's ZPD, and provides emotional support for students (Bennett, 2021; Eun, 2019; Hedges, 20121; Roth, 2017; Vygotsky, 1978). Moreover, some of the MKO's functions may be performed by other students during collaborative activities (Erbil, 2020; Vygotsky, 1978). In modern society, the face-to-face method of delivery includes in-person instructions enhanced by educational technologies that play the role of facilitators of learning (Alaniz et al., 2017; Sweller et al., 2011).

Blended Learning

Blended learning uses both face-to-face and online learning activities in various combinations (Erbil, 2020; Lu et al., 2018; Mullen, 2020; Thai et al., 2019). Lu et al. (2018) noted that blended learning recently gained popularity as an evidence-based strategy. Thai et al. (2019) maintained that blended learning combines the benefits of face-to-face learning and online learning. If well-organized, it may increase students' engagement and facilitate their learning. Erbil (2020) described the flipped classroom as one of variations of the blended learning setting, where passive learning processes occur outside the classroom. For instance, students read assigned materials or watch a video at home. All other activities that require interactions with a teacher and/or peers (e.g., problem-solving, assessments, projects, among others) happen in the classroom. This setting allows the use of collaboration and cooperation with peers, as well as individual work under the teacher's supervision. The teacher provides constructive feedback and assistance immediately as needed. Lu et al. (2018) warned educators about possible difficulties in the practical implementation of blended learning. Researchers found that it is difficult to monitor students' independent work when they are at home, particularly with at-risk students, including those with special needs.

Online Setting

Woodward and Ferretti (2014) defined the online setting as an educational model in which students receive academic instructions via integrated ICT. These instructions can be synchronous (when instructors and students are present and work online at the same time) and asynchronous (when each participant works independently, without direct interactions). Researchers have reported that this method of delivery may lead to a significant improvement in students' academic performance (Erbil, 2020; Thai et al., 2019). The research studies also demonstrated that the online setting is beneficial for learners with health issues, social anxieties, or with family responsibilities that complicate their face-to-face learning (Mullen et al., 2020; Thai et al., 2019). At the same time, other findings demonstrated that the lack of communication during the learning process may negatively impact learners' academic performance and emotional status (Dousay & Trujillo, 2019; Ibrahim & El Zataari, 2020; Thai et al., 2019). In addition, the implementation of educational technology and online learning may be a very costly and complex process (Erbil, 2020). To successfully use it, all stakeholders (including teachers, students, and parents) should receive extensive training and customer support (Erbil, 2020; Mullen, 2020).

Applications of ICT in Different Settings

In each of the three settings, educators may use online tools, such as online lectures, multimedia presentations, discussions, web-supported textbooks, video files, and social-media platforms (Alaniz et al, 2017; Lee & Mayer, 2018). Demir (2018) suggested using social media for online peer and instructor assessments. Walker et al. (2017) have demonstrated that augmented reality (AR) and artificial intelligence (AI) can be effective in any setting. However, both online and blended settings often operate with specialized technologies or Learning

Management Systems (LMS). For instance, Blackboard, Canvas, Odysseyware, and other LMS were designed for online learning. Lu et al. (2018) reported that the Online Assessment Systems (OAS) or Massive Open Online Courses (MOOCs) were beneficial in blended and online learning settings.

Academic Performance in Different Settings

Multiple research studies have examined varied factors that may affect learners' academic achievements. Among them are the individual's level of intelligence, emotional well-being, study motivation, self-efficacy, personality type, and adaptive coping (Bandura, 2001; Bandura & Walters, 1963; Crede & Kuncel, 2008; Rand et al., 2011). Tinto (2012) approached this issue from a social perspective. He suggested that students' social integration into the campus community may prevent dropout from schools. Currently, Tinto's model often provides support for students both academically and socially in various institutional practices. The other factors include demographics, grade point average (GPA), parental educational level, parental involvement, and socioeconomic status (Bandura, 2001; Bandura & Walters, 1963; Crede & Kuncel, 2008; Rand et al., 2011; Tinto, 2012).

Vygotsky's (1978) theory of social learning stated that human development depends on social interactions with the MKO. Thus, students' relationships with their peers and teachers may influence their ability to perform in the classroom. In his theory, Vygotsky maintained that the academic achievement of learners greatly depends on the MKO's scaffolding abilities, i.e., on the instructor's abilities to provide the support needed for working in the students' ZPD. Therefore, instructions should be differentiated, and evaluation of academic performance should be based on the progress within the ZPDs (Vygotsky, 2017). Vygotsky also emphasized the

importance of the ZPD-appropriate educational environment where students can actively participate in the learning process (Vygotsky, 1978).

Additionally, researchers reported that learners' preferences for the settings varied in different studies (Kulikowski et al., 2022; Lazarevic & Bentz, 2021; Mullen, 2020). Mullen (2020) maintained that researchers and educators should consider students' attitudes and preferences and their self-perception of learning outcomes. Mullen (2020) suggested that students prefer e-learning due to its flexibility and self-pacing characteristics. On the contrary, Kulikowski et al. (2022) stated that only 10% of students prefer fully online learning. According to Kulikowski et al., blended learning was the most popular, followed by face-to-face instructions. Researchers suggested that students' communication needs are unequally satisfied in different settings. Apparently, depending on the research design and other factors, each of the three settings had proponents and opponents among participants (Kulikowski et al., 2022; Lazarevic & Bentz, 2021; Mullen, 2020).

Vygotsky's principles of the student-centered learning environment (sometimes combined with other theories) became a theoretical framework for multiple present-day research studies on students' academic performance in different academic settings (Erbil, 2020; Joosten & Cusatis, 2020; Lu et al., 2018; Thai et al., 2019). Even after many years of international debates, there is still no consensus on this topic among scholars. While some findings have demonstrated improved academic performance in the face-to-face setting (Dendir, 2019; Kim & Huynh, 2008), others have shown that the online and/or blended settings were more effective (Dendir, 2019; Lu et al., 2018). There have also been studies that did not find any significant difference between students' academic performance related to the educational setting (Mullen, 2020; Lucky et al., 2019; Thai et al., 2019). That is why many researchers have called for additional investigations

of this issue (Dendir, 2019; Erbil, 2020; Joosten & Cusatis, 2020; Lazarevic & Bentz, 2021; Lucky et al, 2019; Mullen, 2020; Thai et al., 2019).

Summary

Each of the three main educational settings, namely, face-to-face instructions, online setting, and blended learning, has its supporters and opponents. However, Lu et al. (2018), Mullen (2020), and Thai et al. (2019) argued that positive and negative influences of different educational settings academic performance are still under-investigated. One major limitation in related research studies was the fact that students had the opportunity to choose among the settings (Kulikowski et al., 2022). This choice may represent these students' individual preferences, skills, life circumstances, and needs, consequently affecting their academic outcomes. In the spring of 2020, due to the COVID-19 pandemic, governments in many countries mandatorily placed millions of students of all ages and abilities in the online setting. According to a research classification (Gall et al., 2007), this was a natural experiment because investigators did not control the experimental and control conditions for participants. The next section reviews the latest findings on this topic of *forced e-learning*.

Forced e-Learning During the COVID-19 Lockdowns

Many authors have reported the findings about the effectiveness of multimedia technologies in education (Alaniz et al., 2017; Brasier et al., 2019; Kates et al., 2018; Lu et al., 2018; Wise, 2019). In most investigated cases, students had the option to choose the preferred academic setting for their course, including online or face-to-face instruction delivery. However, due to the pandemic situation with COVID-19 during the 2020-2021 school year, educators and students had to move rapidly from face-to-face to online learning (Anderson et al., 2021; Kulikowski et al., 2022; Smith et al., 2020). Kulikowski et al. (2022) named that phenomenon

forced e-learning and defined it as an emergent and involuntary form of communication between teachers and students. Smith et al. (2020) stated that there is a high demand in professional literature that investigates the impact of *forced e-learning* on students' academic performance and their general well-being.

COVID-19 and Forced Online Learning

Lin and Shek (2021) studied the satisfaction and learning outcomes of college students during their transition from face-to-face to an online setting in the spring of 2020. They reported that their findings demonstrated the effectiveness of both settings. At the same time, Reisenwitz and Fowler (2021) conducted a similar study and found that students with higher GPAs had a more positive attitude toward online classes and less transition anxiety. On the contrary, students with lower GPAs demonstrated lower satisfaction and higher levels of stress and anxiety related to that transition. Herold and Chen (2021), who also investigated students' transition experience during the COVID-19 lockdown, identified several factors that negatively impacted academic performance in the *forced e-learning*: (a) decreased access to technology; (b) changes in work responsibility; (c) physical illness; (d) the need to care for others; (e) increased stress; and (f) decreased ability to focus. Herold and Chen noted that more than 50% of students and teachers did not have prior experience with online courses and did not plan to participate in this setting before the pandemic.

Researchers found that COVID-19 significantly changed the dominant modes of education in many countries (Kulikowski et al., 2022). Kulikowski et al. listed six characteristics of *forced e-learning* that affected the work conditions for teachers. First, e-learning decreased task identity for both teachers and students because it became difficult to determine what assignments should be given and to what extent they should be completed. Second, e-learning

decreased the task significance to the point that instead of rational performance, participants started demonstrating symbolic performance. Third, *forced e-learning* increased the skill variety required from teachers and students. Fourth, these changes in job requirements did not change feedback from supervisors. Fifth, e-learning significantly decreased teachers' autonomy at work. Sixth, e-learning decreased social dimensions of work. Consequently, teachers' motivation at work, as well as students' engagement and learning outcomes, decreased.

In their case study, Lambert and Schuck (2021) described the challenges that one special education math teacher experienced while working with SWD online. Apparently, the main challenge was to keep students engaged and focused. Another issue was the need to support students' emotional and cognitive self-regulation during online lessons. Anderson et al. (2020) named several negative effects of the pandemic that impacted the learning process, namely, students' disengagement, social disconnection, and issues of trauma, stress, and technological equity. However, the fact that teachers and students used their adaptive and creative coping skills, researchers considered as a positive effect (Anderson et al., 2020). Researchers investigated how teachers' and students' creativity was linked to their well-being during the COVID-19 school shutdowns (Anderson et al., 2020; Patston et al., 2021). The findings demonstrated that a creative growth mindset and positive attitudes had a strong correlation with improved self-efficacy and motivation. Despite all the negative moments and consequences of *forced e-learning*, stakeholders agreed that children should be able to access educational opportunities regardless of the delivery mode of instruction (Thompson & Nygren, 2020).

Learning Loss Related to the COVID-19 Shutdowns

Learning loss related to the COVID-19 school shutdowns is defined as a significant decrease in academic performance that occurred after schools worldwide ceased their in-person

instruction during the second semester of the 2019-2020 school year to prevent the spread of the COVID-19 pandemic (Sass & Goldring, 2021). At that time, distance teaching or e-learning replaced traditional face-to-face instructions in physical classrooms (Lin & Shek, 2021). Multiple stakeholders reported learning loss as the unintended consequence of this transition. According to Sass and Goldring (2021), who studied student achievement growth during the COVID-19 pandemic in Georgia (Metro-Atlanta schools), students in some schools lost the equivalent of 3-7 months in areas of reading and math. The researchers suggested the implementation of various mediation strategies, such as support to at-risk students and extended learning opportunities for them during summer or other breaks.

Halloran et al. (2021) analyzed scores from standardized tests administered in the USA in 2021. Their findings demonstrated highly significant learning loss in all academic areas caused by remote schooling. This study showed that students who attended the face-to-face setting at that time demonstrated much less decrease in academic performance. Former Education Secretary Dr. Bill Bennett (2021) felt so strongly about this topic that he argued that parents should pull students out of school before *surrendering* them to remote learning, where children were being neglected. Many stakeholders agreed that in-person schooling is crucial for learning; that is why this issue should be further investigated.

Summary

Mandatory or *forced e-learning* during the COVID-19 pandemic revealed several issues with the universal implementation of an online academic setting. Firstly, multiple researchers found a significant learning loss in students who took online classes compared to those who attended face-to-face settings at that time (Halloran et al., 2021; Lin & Shek, 2021; Sass & Goldring, 2021). According to these studies, academic achievement in the areas of reading and

math were significantly lower in the online setting. Additionally, studies showed that students' and teachers' motivation and emotional well-being significantly decreased during that time (Herold & Chen, 2021; Kulikowski et al., 2022; Reisenwitz & Fowler, 2021). However, Lin and Chen (2021) reported that both settings were effective for college students. Also, Reisenwitz and Fowler (2021) noted that students with higher GPA positively evaluated this transition from the traditional to online classroom. Researchers also found that creativity in students and teachers improved their coping skills, resilience, and motivation (Anderson et al., 2020; Patston et al., 2021). Among the multiple factors that negatively impacted learning outcome in the mandatory online setting, researchers named health issues of participants and their family members, increased stress and anxiety in students and teachers, decreased access to technology, technological and academic unpreparedness, social disconnection of all stakeholders, as well as students' disengagement and lack of self-regulation skills (Herold & Chen, 2021; Kulikowski et al., 2022; Lamber & Schuck, 2021; Lin & Shek, 2021). Finally, the research indicated that SWD and at-risk students experienced the lowest achievement growth across all subjects (Halloran et al., 2021; Lin & Shek, 2021; Sass & Goldring, 2021). The following section examines the academic performance of SWD in different settings.

Academic Performance of SWD in Different Settings

Bandura (2001) defined academic achievement as the extent to which individuals attained their educational goals. Students with disabilities (SWD) are students with special needs (emotional, mental, or physical disabilities) who fail to make progress in a regular school setting (O'Brien & Beattie, 2017). Multiple researchers have investigated this topic in the past and continue to work on it in the present. Thus, Swanson and Malone (1992) analyzed 92 research studies about the social skills of SWD. In 1999, Swanson et al. conducted a meta-analysis of 270

studies that aimed to improve these students' academic performance. As the result of this research, Swanson et al. (2014) published the comprehensive seminal work *Handbook of Learning Disabilities*, in which Swanson et al. collected the best practices and interventions that support the academic performance of SWD. The following section presents the information about the inclusion of SWD, discussing some interventions and strategies that improve SWD's learning outcomes in different educational settings.

Inclusion of SWD in Face-to-Face Setting

Vygotsky's research in pedology and his sociocultural theory (Vygotsky, 1931; Vygotsky, 2017) provided a theoretical framework for special education and its main principles (Mecacci, 2021; Sikhova et al., 2020; Stetsenko, 2017). These principles include the following assumptions: (a) diversity is expected and valued; (b) it is wrong to compare individuals with the norms; (c) a socially inclusive learning environment is beneficial for everyone; (d) there are multiple ways to acquire knowledge, (e) competitive activities are socially constructed and can be avoided; and (f) collaboration and cooperation are the preferred forms of human communication (O'Brien & Beattie, 2017). The body of literature about modern special education reflects its multi-disciplinary approach, which includes psychology, neuroscience, and physiology, as well as cognitive, educational, and computer sciences, combined with the latest legislation and regulations (Cinquin et al., 2019). The concept of the inclusion of SWD in public education is one of the most important concepts in special education in the USA (IDEA, 2004; O'Brien & Beattie, 2017).

School-related disabilities. Society often perceives the term *disability* as a characteristic of an individual with a noticeable physical or mental disorder that significantly impacts the quality of life of said individual (O'Brien & Beattie, 2017). However, most students with special

needs have mild disabilities that are difficult to notice outside of the academic environment. These are *school-related disabilities*. Approximately 94% of students with disabilities receive services under five high incidence categories, namely specific learning disabilities (SLD), speech and language impairment (SLI), other health impairments (OHI), mild intellectual disability (MID), and emotional-behavioral disturbance (EBD). Students with medical diagnoses of autism spectrum disorder (ASD) and Attention-Deficit-and-Hyperactivity Disorder (ADHD) receive services depending on the specifics and severity of their conditions.

The special education continuum of services in a face-to-face setting. Historically, SWD did not participate in social life and public education (O'Brien and Beattie, 2017; Rossa, 2017). However, in the middle of the twentieth century, the special education continuum of services, named the Least Restrictive Environment (LRE), addressed the educational needs of these students (IDEA, 2004; Lemons et al., 2018; O'Brien and Beattie, 2017; Rossa, 2017). The LRE mandates inclusion of SWD into general education to the maximum possible extent that is beneficial to a student (IDEA, 2004). The special education continuum of services provides SWD with access to the following types of face-to-face classrooms: General education, general education inclusion with consultative support from special education teacher, general education inclusion with support from a paraprofessional, and general education inclusion with a co-teacher (i.e., special education teacher who works alongside with a general education teacher) (IDEA, 2004; O'Brien and Beattie, 2017; Lemons et al., 2018). In 2019, 65% of SWD received special education services in one of these classes for 80% or more of their school day. Consequently, 35% of SWD in public K-12 schools attended other special educational classrooms, such as small group classes, special schools, or were either home- or hospital-bound (NCES, 2022). However, federal law requires more than students' placement in the LRE.

Various educational interventions and strategies ensure the development of SWD and their academic progress (IDEA, 2004; O'Brien and Beattie, 2017; Lemons et al., 2018).

Interventions and Strategies for SWD

Scholars agreed that special education is essentially applied developmental science (Clara, 2017; Farmer et al., 2016; Hedges, 2021; Stetsenko, 2017; Swanson et al., 2014). That is because special education synthesizes multiple disciplines, such as psychology, biology, education, genetics, and neurosciences, economics, and social studies, to examine an individual's adaptation, growth, and outcomes (Cinquin et al., 2019; Farmer et al., 2016). Both special education and developmental science focus on students' malleability, problem behavior, intervention support, and services. Special education and developmental science also employ research, person-oriented analysis, and interventions (Farmer et al., 2016; Mecacci, 2021). However, Farmer et al. (2016) warned that it is not enough to find a proper evidence-based strategy or intervention because SWD are often resistant to such interventions. Therefore, educators and intervention specialists must intensify and individualize these strategies. Farmer et al. (2016) maintained that adaptation for SWD does not stop with their adjustment to the school rules and curriculum. Special education aims to prepare SWD for the future, after they graduate from high school. In that sense, development is a process of individuals and contexts adapting to each other, while education is a process of adjustment to the environment (Farmer et al., 2017; O'Brien & Beattie, 2017). For that purpose, the Individualized Education Plan (IEP) regulates education of SWD in the USA (IDEA, 2004).

Classroom accommodations. According to federal law, every child with disability (ages 3-21) must have an IEP that provides adequate progress appropriate to their abilities and circumstances (IDEA, 2004; Lemons et al., 2018; O'Brien & Beattie, 2017). Each IEP is unique

and highly personalized. All special education services (e.g., school, mental health, related services agencies) participate in the IEP development and implementation. The IEP identifies developmental goals in areas of weaknesses, including students' life skills and transitional goals. Additionally, the IEP goals prescribe differentiations and accommodations in instructions and assessments (IDEA, 2004).

Various instructional and testing accommodations are the most common interventions in special education (Lemons et al., 2018; O'Brien & Beattie, 2017). Educational researchers continue examining their objectives and efficacy. Lewandowski et al. (2020) argued that there is no empirical evidence for many traditional accommodations. For instance, extended time is the most widely used accommodation, but students without disabilities benefited from it more than their peers with disabilities. Another popular accommodation, a private room for testing, was beneficial only for students with ADHD who needed additional opportunities to focus on assignments. In 2008, Kim and Huynh compared the results of paper-pencil versus computer-based testing in English language arts. The researchers found that the latter was more difficult for test-takers, especially in the reading comprehension section. In their research, Knoop-van Campen et al. (2019) demonstrated that adding audio-support for all children, regardless of their disability status, can lead to improved academic performance. This outcome is especially noticeable in children with dyslexia; that is why the read-aloud support was beneficial for many students.

To facilitate the learning of SWD, the IEP team, consisting of a student, parents/guardians, teachers, school administrators, and other appropriate specialists, decides what accommodations are needed in each case (IDEA, 2004; O'Brien & Beattie, 2017). Students with the same category of disability can have completely different sets of classrooms and testing

accommodations, depending on their individual needs and abilities (IDEA, 2004). However, Kotera et al. (2018) and Kent at al. (2018) found that college SWD often do not disclose their special needs and do not receive special education support. Consequently, their academic outcomes become negatively impacted. It is particularly important for SWD to be able to self-advocate, which means vocalizing their needs and defending their legal rights to receive accommodations (Holzberg et al., 2019).

Neuroscience. School-related disabilities include various physical and mental disorders (IDEA, 2004). According to the National Center for Education Statistics (NCES, 2021), 7.3 million (that is, approximately 14%) SWD attended U.S. public schools in 2019. Among these students, 33% received services for SLD, 19% for SLI, and 15% for OHI, including ADHD. In addition, almost 11% of SWD received services for ASD. Even though the graduation rate for public high school 4-year cohorts in the USA was 85.8% in 2019, only 68.2% of SWD graduated that year (GOSA, 2019; NCES, 2022).

Applications of neuroscience in special education allow researchers to help SWD by developing new effective diagnostic, medical, psychological, and educational interventions. Many researchers, including Vygotsky (2017), Luria (1976), Kostyanaya (2015), and Kovyazina (2017), investigated the issues of neuropsychology. Research findings demonstrated that brain structures and functions of individuals with and without disabilities are noticeably different (Clara, 2017; Farmer et al., 2016; Hedges, 2021; Luria, 1976). Therefore, neurophysiological and neurobiological examination of young children may help researchers predict future disability and, in some cases, prevent it by providing appropriate intervention.

For instance, future reading complications are predictable as early as 5 months of age by identifying early auditory processing issues (Farmer et al., 2016). In this case, the three-hour

training for an infant was enough to significantly improve the child's brain functioning in this area. Smith and Ayres (2016) demonstrated that persistent pain experienced by learners can negatively impact their cognitive and emotional development. Pecor et al. (2016) found that a lack of sleep because of overuse of mobile phones may negatively impact adolescents' academic performance in school. Another example is the development of brain structures and functions responsible for emotions and self-regulation (Farmer et al., 2016). School success largely depends on how the child meets behavioral expectations in the classroom (focuses attention, follows directions, communicates with peers and teachers, among others). However, students with and without disabilities are vastly different in this domain. SWD in all categories exhibit the highest level of behavior problems, peer rejection, peer victimization, discipline issues, crime participation, and dropout rates (Farmer et al., 2016; Hedges, 2021; Ratner & Efimova, 2016).

Psychological and psychotherapeutic interventions. Students with special needs often demonstrate underdeveloped executive functioning and self-regulation, low motivation, testing anxiety, stress, behavioral issues, and problems with self-advocacy (Farmer et al., 2016; Hedges, 2021; Ratner & Efimova, 2016; Swanson et al., 2014). Knoop-van Campen et al. (2019) noted that executive functions are important predictors of academic progress, as they control and regulate non-automatic behavior. These functions include higher level cognitive processes, working memory, self-regulation, inhibition of automatic responses, and cognitive flexibility, which are necessary for successful transition between activities. Having such deficits, SWD may benefit from psychological and psychotherapeutic interventions that address their cognitive, social, and emotional development. Theorists and practitioners from various theoretical schools are actively working on developing training programs to improve students' executive functions (Dubuc et al., 2020; Ratner & Efimova, 2016; Schneider et al., 2020).

Emotional issues, such as stress and anxiety in children of all ages, often require medical and/or psychotherapeutic interventions. Many researchers examined the relationships between academic achievements and testing anxiety (Soares & Woods, 2020; Steinmayr et al., 2016; Wise, 2019; Yang et al., 2017; Zeidner, 1998), math anxiety (Johnson et al., 2021), stress (Lazarevic & Bentz, 2021), social anxiety (Van Zalk & Van Zalk, 2018), and anxiety related to the use of multimedia and technologies (Camacho et al., 2018; Guo, 2016; Lapierre et al., 2019; Meter & Bauman, 2018). These studies supported the idea that negative emotions and anxiety can have adverse effects on the academic performance of learners. Consequently, teachers, parents, and students should be prepared to address these issues (Lazarevic & Bentz, 2021). Recommended interventions include teaching students coping skills and self-regulation (Johnson et al., 2021; Lazarevic & Bentz, 2021; Soares & Woods, 2020; Swanson & Malone, 1992), as well as implementing anti-bullying and anti-cyberbullying programs (Camacho et al., 2018; Guo, 2016; Lapierre et al., 2019; Meter & Bauman, 2018).

Students with EBD often externalize their emotional issues through aggression and defiant behaviors (O'Brien & Beattie, 2017). Gottfried and Kirksey (2019) reported that students with EBD had lower grades compared to their non-disabled peers. Moreover, multiple research studies have found that non-disabled students who had students with EBD in their class, showed lower test scores and higher absenteeism along with a higher rate of disciplinary infractions compared to students from non-inclusive classes (Gottfried and Kirksey, 2019). Among other strategies, Gottfried and Kirksey (2019) suggested increasing the number of girls in classes with students with EBD to mitigate these issues. They also found that writing assignments may improve behaviors of students with EBD. Losinski et al. (2020), who conducted the meta-analysis of math interventions for students with EBD, stated that there is an urgent need in the

evidence-based practices that address the cognitive and social development of this group of students, as well as teachers' readiness to work with them.

The lack of learning motivation is common among SWD. It can be caused by any of the emotional or psychological deficiencies, as well as by insufficient organization of the learning process. Therefore, interventions should address both these causes. Maslow's theory of motivation (1954) included the concept of self-actualization, which refers to the desire to become a better version of oneself. This idea is similar to Vygotsky's concept of *Superman* (2017). According to Maslow (1954), the inability to achieve self- actualization often leads to profound disappointment in life and depression, while anxiety can arise when individuals perceive threats to their needs, such as self-esteem, life goals, and self-actualization. Kenrick (2017) and Noltemeyer et al. (2020) have extended Maslow's theory, incorporating the latest research in biology, social sciences, and psychology. Kenrick (2017) identified Maslow's theory as a precursor to modern evolutionary psychology. He classified self-actualization under the self-esteem group of motives due to its affiliation with social status and success. Additionally, Kenrick (2017) emphasized that an updated Maslow's hierarchy of needs is essential for understanding multiple social problems and human motivations in modern society. Thus, academic success is a direct result of students' attempt to achieve said self- actualization while being a part of their social group. Noltemeyer et al. (2020) examined Maslow's theory and reported that students' access to safety needs (i.e., health and dental care) and their sense of belonging to school were the most essential factors of academic success.

Educational strategies. Specific Learning Disabilities (SLD) are characterized by unexpectedly low academic achievements in students without intellectual impairments (APA, 2013; IDEA, 2004; O'Brien & Beattie, 2017; Swanson et al, 2014). In their *Handbook of*

Learning Disabilities, Swanson et al. (2014) collected the best practices that facilitate the academic development of students with SLD in different content areas, as well as their social well-being. Inclusion, mainstreaming, and resource rooms provide the needed teacher's support for SWD. Focusing on reading interventions, improving word recognition, and reading comprehension allows them to acquire knowledge in all academic areas. The multisensory approach, breaking instructions into smaller steps, and scaffolding positively affect these students' learning outcomes. Swanson et al. also emphasized the role of a teacher who announces objectives of a lesson, gives presentations, provides direct instructions, conducts daily reviews, supervises individual practice, and organizes formative assessments followed by timely feedback.

One of the effective research-based practices is Universal Design for Learning (UDL) (CAST, 2011; O'Brien & Beattie, 2017). The Center for Applied Special Technologies (CAST, 2011) created UDL to address the learning needs and abilities in students with and without disabilities. UDL supports three main principles, namely, providing students with multiple means of representation (i.e., *what?*), actions/expressions (*how?),* and engagement (*why?*). The UDL framework helps teachers create highly differentiated instructions. In terms of sociocultural theory (Vygotsky, 2017), flexible goals, methods, materials, and assessments allow for the identification of ZPD and the delivery of instructions via mediations with a variety of tools during the interactive learning process. UDL became popular almost immediately after its introduction to the special education community because multiple research studies demonstrated its effectiveness (O'Brien & Beattie, 2017; Walker et al., 2017).

It is important to know that SLD in math and reading are the two most common subtypes of learning disabilities (Swanson et al., 2014). Losinski et al. (2019) argued that math proficiency

is the crucial skill that may determine the learners' academic success in school. SWD frequently demonstrated a lack of math skills and knowledge (Gottfried & Kirksey, 2019; Roth, 2017; Walshaw, 2017). Joyner and Wagner (2020) stated that SLD in reading and math are often intertwined. The researchers reported that students with reading disability also had math disability twice as often as their peers without reading problems. Joyner and Wagner suggested that there are two possible reasons for that. First, both math and reading operate with symbols, which is why the deficit in this area impacts both skills equally. Second, the process of solving math problems involves reading comprehension. The low level of reading skills causes a loss in math outcomes (Joyner & Wagner, 2020). That is why educational interventions should address reading and math deficits simultaneously. Research findings suggest that this goal may be achieved via multimedia instructions in blended and online settings (Alaniz et al., 2017).

Blended Learning for SWD

Blended learning combines face-to-face and online instructions (Erbil, 2020; Lu et al., 2018; Mullen, 2020; Thai et al., 2019). Kulikowski et al. (2022) reported that students with and without disabilities preferred blended learning to face-to-face and online settings. Research studies have demonstrated that this method of delivery provides the benefits of the other two settings (Lu et al., 2018; Thai et al., 2019). Erbil (2020) maintained that blended learning allows SWD to collaborate with peers, as well as receive the teacher's constructive feedback and assistance immediately. That is important for SWD who often lack self-regulation skills. However, Lu et al. (2018) noted that it is difficult to monitor SWD's independent homework. This potential drawback can negatively affect academic performance of SWD.

In 2022, Topping et al. conducted a systematic analysis of the effectiveness of online and blended learning. Among other effective digital tools, authors listed educational games,

computer-supported cooperative learning, and computer-assisted instructions. Topping et al. reported that, according to the results of 1355 studies, digital instructions were more effective in 85% of studies, the same in 8% of studies, and less effective in the remaining cases. Blended learning had the highest academic outcomes, considerably better than online learning. Self-efficacy scores of students also increased. According to this study, students from elementary schools benefited most from computer-assisted instructions, digital games, and computer-supported cooperative learning. Topping et al. concluded that SWD performed slightly worse in online and blended settings compared to their peers without disabilities. The authors concluded that digital technologies may enhance task flexibility and learner self-regulation in some students, but this may not be an advantage for others.

Online Setting and SWD

Educational technologies and multimedia provide additional support to all groups of students (Haw, 2018; Lee & Mayer, 2018; Vanderburg et al., 2021; Walker et al., 2017). Often, ICT and multimedia work as interactive learning systems in the online and blended settings (Cinquin et al., 2019; Edmentum, n.d.; Leite et al., 2019; Odysseyware, n.d.). Multiple studies have demonstrated that technologies may improve academic outcomes of SWD, as well as their emotional and social well-being (Cinquin et al., 2019; Dendir, 2019; Kent et al, 2018; Kotera et al., 2019; Schrader et al., 2018; Schwan et al., 2018; Sublett & Chang, 2019). For instance, Kent et al. (2018) argued that SWD prefer online learning. Also, Sublett and Chang (2019) reported that the graduation rate of SWD is higher in the online setting, while Dendir (2018) stated that students' ability to self-select their course setting may positively affect their learning outcomes. Moreover, Schwan et al. (2018) and Schrader et al. (2018) demonstrated that learners' intrinsic motivation is higher when they use multimedia tools. In addition, Kotera et al. (2019) found that

SWD preferred online courses for the ability to control their own path, the *personal touch* from their instructor, and a decreased level of social stress. Finally, Cinquin et al. (2019) emphasized that e-learning is one of the critical tools for improving access to education and to the full social inclusion of SWD.

On the other hand, there were research studies that reported negative effects of educational technologies on SWD. Researchers found that many students, despite having extensive experience with digital technologies for personal communication and entertainment purposes, lack the productive skills needed for their classes (Uzun & Kilis, 2019). Recently, several research studies reported that SWD demonstrated a significant decrease in their academic achievements after being forcefully placed into an online setting (Halloran et al., 2021; Lin & Shek, 2021; Sass & Goldring, 2021). Also, unsupervised access to the internet, social-media, mobile phones, among others, led to distractions during the learning process, and, consequently, lower academic performance (Kates et al., 2018). In addition, parents and educators expressed their concerns that children can become easy targets for online predators (Camacho et al., 2018; Meter & Bauman, 2018). Finally, findings suggested that online courses may have more cases of cheating and academic dishonesty (Lucky et al., 2019; Wise, 2019).

After a detailed analysis of the best evidence-based practices, Serianni and Coy (2014) compiled a list of the seven support strategies for SWD who take online courses. Support strategies begin with the recommendation to carefully select an online course that suits the given group of students because the quality of the course plays a deciding role. Also, it is important to choose an online teacher who is prepared to work with SWD. After that, administration should acquire technologies that are appropriate for that course. Then, instructors should identify and provide special education support during all educational activities. Next, they should prepare a

well-organized physical learning environment. Finally, a learning coach/facilitator should provide continuous technical support (Alaniz et al., 2017; Serianni & Coy, 2014).

Summary

In 2019, approximately 7.3 million students in the U.S. K-12 public schools, which accounted for almost 14% of student body, received special education services (GOSA, 2019; NCES, 2021). At least 94% of these students had one of the high incidence school-related disabilities that negatively affected their cognitive, emotional, and social development (O'Brien & Beattie, 2017). The inclusion of SWD into traditional face-to-face classrooms called for the implementation of various strategies and methods aimed at improving these students' learning outcomes (Lemons et al., 2018; O'Brien & Beattie, 2017; Rossa, 2017; Swanson & Malone, 1992; Swanson et al., 1999; Swanson et al., 2014). Special education, as an applied developmental science, synthesized multiple disciplines, such as psychology, pedagogy, and neuroscience to serve the needs of SWD (Clara, 2017; Hedges, 2021; Mecacci, 2021; Stetsenko, 2017). Researchers have explored the effectiveness of educational technologies and their applications in different educational settings, including face-to-face instruction, blended learning, and online settings. However, there is still no consensus in the findings. While some researchers reported that SWD may benefit from online setting (Cinquin et al., 2019; Dendir, 2019; Kent et al, 2018; Kotera et al., 2019; Schrader et al, 2018; Schwan et al., 2018; Sublett & Chang, 2019), another group of researchers demonstrated that face-to-face instructions allow SWD to improve their academic performance at a higher rate (Eun, 2019; Hedges, 20121; Roth, 2017). Proponents of blended learning suggested that this is the most effective and efficient method for all students, including SWD (Erbil, 2020; Kulikowski et al., 2022; Lu et al., 2018; Mullen, 2020; Thai et al., 2019; Topping et al., 2022). Considering that SWD often exhibited a lack of math skills and

knowledge (Gottfried & Kirksey, 2019; Roth, 2017; Walshaw, 2017), the following section overviews the findings on the effectiveness of math instructions in different settings.

Math Education in Different Settings

Roth (2017) maintained that Vygotsky's theory is the most appropriate for explaining the phenomena of math education. Modern scientists frequently use Vygotsky's concepts (1962), such as social learning, educational environment, active learning process, scaffolding, zones of proximal development, and others. However, they do not always acknowledge his contributions in the theoretical frameworks of their studies (Roth, 2019b; Walshaw, 2017). More often, readers can observe connections to alternative theories, such as Bandura's social cognitive theory (2001), Sweller's cognitive load theory (1994), and Mayer's multimedia learning principles (2009). In the following section, the author analyzes several studies relevant to the present research.

ICT in Math Education

A plethora of research studies have examined various aspects of math education in different academic settings. For instance, Krouss and Lesseig (2020) examined the effect of a flipped classroom model in an introductory college math course. Similarly, Francis et al. (2019) examined differences in motivation and academic outcomes between online and face-to-face community college developmental mathematics courses. Moreover, Bergeler and Read (2020) compared learning outcomes and satisfaction in an online algebra-based physics course and its face-to-face counterpart. Also, Leite et al. (2020) investigated the relationship between students' participation in an online tutoring platform and their Algebra I EOC test scores. Additionally, Hwa (2018) studied the application of digital game-based learning in math education. Later, Rusk and Ronning (2020) observed and attempted to explain how students organize their cooperative work in STEM classes. Also, Harris et al. (2019) tested the psychological

interventions for reducing test anxiety and stress, examining their effects on the academic achievements of students taking STEM courses. Recently, Gershenson (2020) analyzed how inflated GPAs negatively impacted students' performance on Algebra I EOC assessments.

The main goal in all these studies was to investigate the factors, including educational setting, which influence academic performance, engagement, and/or motivation in students taking math or STEM courses. Hwa (2018) found that multimedia and digital game-based learning improve the positive attitude and motivation of young children in mathematical learning. Hwa reported that this method was more effective than traditional class-based math education in terms of academic achievements. Rusk and Ronning (2020) maintained that providing students in math and science with an opportunity to participate in *hands-on* activities is beneficial to their learning outcomes. Researchers stated that more than 600 studies and 100 projects demonstrated that exploratory methods lead to greater productivity, better academic performance, improved social competence, and coping skills for stress and anxiety. Harris et al. (2019) reported that psychological interventions for mediating test anxiety improved academic outcomes in 1140 college students. These suggestions align with Vygotsky's principles of active learning, which include active teaching, active knowledge acquisition, and an interactive learning environment (Vygotsky, 1978).

Francis et al. (2019) analyzed academic outcomes and motivation in 2,411 developmental math students. The researchers found that online students in community college math classes received lower grades and were less likely to pass compared to their peers in face-to-face settings. At the same time, Leite et al. (2019) reported that the use of an online tutoring system improved the Florida EOC in Algebra I test scores in 3987 high school students who had previously failed the test. However, Bergeler and Read (2020) did not find a difference in

learning outcomes between 116 college students who took an online algebra-based physics course and those who took it in a face-to-face setting. Moreover, Krouss and Lesseig (2020) compared academic performance and satisfaction in an introductory math college course among 329 underperforming students and did not find any significant difference in learning outcomes in different settings. These discrepancies in the results of studies demonstrate a significant gap in professional literature, particularly regarding SWD in math classes.

Mathematical Learning Disability

Approximately 5-8% of students have a diagnosis of a mathematical learning disability (MLD) (Lewis & Fisher, 2016). MLD is a broad term that describes various difficulties with learning basic math (Ostergren, 2013). In professional literature, it may have different names, such as mathematical learning disability, mathematical disability, mathematical difficulty, developmental dyscalculia, among others (Ostergren, 2013). In 2016, Lewis and Fisher analyzed the methodological issues in that area. The authors examined 165 studies on the topic that were published between 1974 and 2013. Their findings demonstrated that researchers are still in disagreement about operational definitions of MLD and related concepts. Lewis and Fisher (2016) suggested that the development of common standards for methodology and reporting may improve future research. They also emphasized the role of precise and shared definitions. Bone et al. (2021), Hughes et al. (2014), Lee et al. (2020), and Nelson et al. (2022) suggested to focus further research studies on exploring effective evidence-based practices for SWD who take math classes through different instructional delivery methods.

Mathematics and SWD in Different Settings

While not all SWD have a diagnosis of MLD, many of them struggle in math classes (Swanson et al., 2014). Multiple researchers investigated the effectiveness of math instructions for SWD in different academic settings (Bone et al., 2021; Hughes et al., 2014; Lee et al., 2020; Nelson et al., 2022). In 2014, Hughes et al. conducted a meta-analysis of 12 studies that examined interventions for SWD in algebra. Lee et al. (2020) analyzed 12 studies of interventions for students with LD in relation to algebraic concepts. Similarly, Bone et al. (2021) reviewed 18 studies on algebra instructions for students with LD. Also, Nelson et al. (2022) conducted a systematic review of 22 meta-analyses of mathematical interventions. Researchers agreed that there is a significant disproportionality in math performance between students with and without disabilities in traditional face-to-face classrooms (Bone et al., 2021; Hughes et al., 2014; Lee et al., 2020; Nelson et al., 2022). According to various sources, despite various interventions and the implementation of evidence-based practices, SWD had 15-26% proficiency in math (Lee at al., 2020). Nelson et al. (2022) stated that gaps in knowledge and skills for SWD emerge at an early age and remain significantly stable over the years. Bone et al. (2021) reported that SWD scored an average 40 points below their peers without disabilities on the National Assessment of Educational Progress (NAEP). The findings about the effectiveness of different settings in math classes for SWD are discussed below.

Face-to-face setting. According to Hughes et al. (2014), multiple researchers have found that SWD may benefit from teacher's instructions and interventions in mathematics in a face-to-face setting. Among these interventions, Hughes et al. identified cognitive/model-based instructions, co-teaching, the concrete-representational-abstract framework, graphic organizer, single-sex interventions, and technology. However, not all interventions had a significant effect

on students' performance. Among all the interventions, explicit teacher's instructions had the largest positive effect. Hughes et al. noted that single-sex interventions had the smallest effect on students' learning outcomes.

Bone et al. (2021) examined 18 studies that investigated 8 mathematical strategies for teaching algebra to secondary students with LD. None of the studies met the criteria of evidence-based practices. The authors identified 5 potentially evidence-based strategies that yielded positive outcome, namely the concrete-representational-abstract framework, manipulative-based approaches, enhanced anchor instructions, schema-based instructions, and peer-assisted learning strategies. On the other hand, three other methods, namely graphic organizers/diagrams, problem-solving strategy, and the virtual-abstract framework, did not have sufficient support in professional literature at the time of the meta-analysis. Bone et al. concluded that further research in this area is needed.

Blended setting. Lee et al. (2020) reviewed 12 studies that aimed to identify effective algebra interventions for secondary students with LD. The results of this meta-analysis demonstrated that the most frequently used strategies included multiple representations, a sequence of examples, and explicit instructions. Both real and virtual manipulatives were found to be equally effective. Lee et al. also reported the effectiveness of student verbalization combined with multiple representations of a concept. These results further support the findings of other researchers who have advocated for the effectiveness of blended setting for SWD (Alaniz et al., 2017; Erbil, 2020; Kulikowski et al., 2022; Sweller et al., 2011).

Online setting. Hughes et al. (2014) reviewed 168 articles about algebra interventions for SWD. The findings have been contradictory. Some researchers have suggested that the online setting is overwhelming for SWD, who may lack self-regulation and technological skills, leading

to their academic underperformance (Kim et al., 2021; Ratner & Efimova, 2016; Shvarts & Bakker, 2019). Consequently, SWD may be more successful in face-to-face or blended settings. Another group of researchers found that ICT can successfully act as a teacher by providing scaffolding and controlling students' steps in the completing their assignments while offering immediate feedback (Clara, 2017; Eun, 2019; Hedges, 2021; Kim et al., 2021). Moreover, Miranda et al. (2017) compared the freedom of digital learning with Montessori's child-centered classroom, where students choose their assignments and control their own pace. MacArthur (2014) reported the effectiveness of ICT-based interventions for SWD in math, reading, writing, and other academic areas, while Wise (2019) suggested that online testing decreases testing anxiety in SWD. The lack of consensus among researchers calls for additional investigation in this area.

Summary

Vygotsky's sociocultural theory of cognitive development (1978), in combination with Bandura's social cognitive theory (2001), Sweller's cognitive learning theory (1994), and Mayer's multimedia learning principles (2009), provides a theoretical framework for the present research. The concepts of social learning, educational environment, active learning process, ZPD, and scaffolding explain many phenomena of modern math instruction and education of SWD. Despite the plethora of studies in these areas, there are still multiple gaps and discrepancies in professional literature that require further research. For instance, each of the three methods of instructional delivery in math (i.e., face-to-face, blended, and online settings) has both opponents and proponents. This conflict is also noticeable in studies that investigate the academic performance of SWD in different settings.

Links to Proposed Study

The present study examined the academic performance of students with and without disabilities who received math instruction in different academic settings. For that purpose, the researcher compared participants' scores on the GA Milestones EOCT in Algebra I conducted in the spring of 2021. The following themes in professional literature clarified the possible approaches to the current investigation: (a) effectiveness of digital technologies, multimedia, and different educational settings; (b) math instruction and strategies; (c) academic achievements of students with disabilities; and (d) the impact of *force e-learning* on the educational process. The next section identifies the gaps in the body of literature.

The Gaps in Professional Literature

Due to the relative novelty of online learning, which began less than 20 years ago, the literature about online learning's effectiveness for diverse groups of learners still does not have the answers to all questions. The major gap in professional literature is the lack of a theory that explains students' academic performance in different academic settings. There is also not enough available data on SWD who became online learners instead of receiving instructions in a face-to face setting during the COVID-19 lockdowns. In these conditions, students received reduced or minimal support from teachers and peers. During that time, they had to mainly rely on educational software and other unanimated sources of information that functioned as their MKOs. The effectiveness of several types of MKOs for students' learning outcomes needs additional investigation. The purpose of this study is to fill that gap by determining if there is a statistically significant difference in the academic achievements of high school students with and without disabilities who had one, two, or zero semesters in Algebra I online.

How the Study Fills the Gap

During the COVID-19 crisis, public schools in the U.S. provided online instructions to all categories of students, regardless of their willingness or ability to work independently (Herold & Chen, 2021; Kulikowski et al., 2022). However, there is not enough research available to address the issue of the effectiveness of the online educational setting for SWD. Even though multiple authors examined groups of students in different educational settings, they mainly focused on the social-emotional experience of participants (Herold & Chen, 2021; Kent et al., 2018; Schwan et al., 2018). In addition, previous studies compared separate groups of students who willingly chose online or face-to-face instruction (Dendir, 2019; Kent et al., 2018; Schrader, 2018; Sublett & Chang, 2019). The present study aims to add to the body of knowledge about the effectiveness of different educational settings for diverse groups of students.

Summary

The cognitive development of SWD is a multidisciplinary topic that is the focus of studies in neuroscience, psychology, education, and special education. Additionally, multiple researchers and practitioners in educational technology use the findings of developmental psychology to improve the effectiveness of ICT in modern classrooms (Alaniz et al., 2017). Various theories have attempted to explain the phenomena that condition the academic performance of SWD. Among them were Montessori's child-centered method (Montessori, 1973), Piaget's theory of cognitive development (Piaget, 1953), Bandura's social learning theory (Bandura & Walters, 1963) and the self-efficacy concept (Bandura, 1986). Gardner's theory of multiple intelligences (Gardner, 2000), Paivio's theory of mental representation (Paivio, 1986), Sweller's theory of cognitive load (Sweller, 1994; Sweller et al., 2011), as well as Mayer's and Moreno' principles of multimedia education (Mayer, 2009; Moreno & Mayer, 2007), have also

investigated the effectiveness of ICT in education. However, Vygotsky's theory of sociocultural development is one of the most complete and versatile theories that explains how the mind of a child forms and develops under different conditions (Van der Veer, 2021; Vygotsky, 1978). According to this theory, cognitive development occurs when a learner socially interacts with a more capable other, who assists in acquiring the skills and concepts through mediation and scaffolding (Valsiner, 2021; Vander Veer, 2021; Vygotsky, 1962). Therefore, teachers should build their instructions and assessments upon the learner's ZPD, because the process of learning happens within it. Vygotsky also emphasized the role of language as the universal tool of knowledge that allows a learner to internalize the concepts into thoughts and mind.

Vygotsky's contemporaries and followers worldwide enriched his theory and extended it into the modern paradigms of education and development. Among the most noticeable extensions were findings in cross-cultural studies and neuroscience (Luria, 1976), activity theory (Leontiev, 1978), scaffolding theory (Bruner, 1986), cultural-historical activity theory (Engestrom, 1987), institutional education (Bernstein, 1970), and many others. These scholars attempted to examine and explain how varied factors may affect students' learning outcome. In the case of SWD, appropriate accommodations and differentiations are not just matters of professionalism or ethics but rather issues of compliance with federal law (IDEA, 2004). Recent calls for papers in that area of research have activated studies on the effectiveness and emotional well-being of learners in different educational settings (Anderson et al., 2020; Kulikowski et al., 2022; Lambert & Schuck, 2021; Smith et al, 2020). The present research study is a response to one of these calls.

CHAPTER THREE: METHODS

Overview

Chapter Three begins with the identification of a research design and provides a rationale for its choice. Next, the research question and null hypotheses establish the direction for the study. Detailed descriptions of the setting and participants introduce the testing site. Finally, information about the study instruments and procedures specifies the validity and reliability of the method. The comprehensive explanation of the applied data analysis concludes the chapter.

Design

The purpose of this quantitative, non-experimental causal-comparative study was to determine whether there is a statistically significant difference in the academic performance of high school students with and without disabilities who receive math instruction in face-to-face and online educational settings. The rationale for choosing this design consisted of three intertwined factors. First, the substantial number of participants (N=588) allowed for the use of a quantitative approach (Gall et al., 2007). Second, non-experimental studies typically involve measuring or observing multiple variables in naturally occurring situations (Warner, 2013). In the present study, these situations included the choice of the educational setting and participation in the state-mandated test. The variables included two independent variables, namely the students' choice of educational setting and their disability status, and one dependent variable, which is the students' scores for the state-mandated Georgia (GA) Milestones End-of-Course Test (EOCT) in Algebra I.

For the purpose of this study, the author used the following definitions of educational settings. Lemons et al. (2018) defined an educational setting as a method of delivery and a context in which students receive instructions. A face-to-face setting is an instructional method

where a teacher delivers course content in person (Lemons et al., 2018; Wise, 2019). An online educational setting is an instructional modality where students receive all instructions via ICT (Wise, 2019). Participants in the present study had to choose between online and face-to-face settings for each of the two semesters in the 2020-2021 school year, resulting in three possibilities: (a) 0 semesters in the online setting, (b) 1 semester in the online setting, and (c) 2 semesters in the online setting. Disability status is defined as the eligibility of SWD to receive special education services under at least one of the twelve disability categories (IDEA, 2004). To identify students with and without disabilities among the participants, the researcher marked their disability status with either *yes* or *no* answers. Students with all categories of disabilities participated in the study. Consequently, participants formed six groups, depending on their choice of educational setting and their disability status.

Finally, the causal-comparative research design was appropriate for this study because it was a non-experimental investigation aiming "to identify cause-and-effect relationships by forming groups of individuals in whom the independent variable is present or absent …and then determining whether the groups differ on the dependent variable" (Gall et al., 2007, p. 306). The current study relied on the observation of naturally occurring relationships between the groups that existed before the beginning of the study. Under these conditions, manipulating the independent variable was not possible (Gall et al., 2007). Thus, this research study had the ex post facto design.

Research Question

The research question for this study was:

RQ: Is there a significant difference in Algebra I skills among high school students based on their disability status and educational setting, taking 0, 1, or 2 semesters online?

Hypotheses

The null hypotheses for this study were:

$H_0$1: There is no statistically significant difference between the Algebra I skills in high school students with and without disabilities, as measured by the Georgia Milestones End-of-Course test scores.

$H_0$2: There is no statistically significant difference among the Algebra I skills in high school students taking 0, 1, or 2 semesters online, based on their educational setting, as measured by the Georgia Milestones End-of-Course test scores.

$H_0$3: There is no statistically significant interaction between the high school students' status of disability and their educational setting (taking 0, 1, or 2 semesters online), as measured by the Georgia Milestones End-of-Course test scores in Algebra I.

Participants and Setting

This section describes the participants and setting for the present study. The depiction of the population includes the demographics and statistics of the region. Next, the information about each group of participants is presented. Then, the researcher shares the sampling technique and sample size for this study. The setting details conclude the section.

Population

The North Georgia school district in this study has diverse demographics. The school district is in a rural community with an estimated population of 42,853 and a student population of approximately 7,854 students (GOSA, 2019; USCB, n.d.). According to USCB (n.d.), in 2020, the median household income was at $48,958, with more than 17.7% of the residents having an income below the poverty level. The percentage of students eligible for free or reduced meals was 85%. The student population was predominantly Caucasian (70%). There also were

Hispanic (14.1%) and Black (13%) students. Additionally, there were Asian (0.8%) and multi-racial students (2.1%) (NCES, n.d.; USCB, n.d.)

Participants

The study employed a convenience sample of 588 high school students who attended 9th through 12th grades in two rural public schools (named school A and school B) in North Georgia in the 2020-2021 school year. At the time of the current research, the school district had two high schools with a total of 2,265 students (1282 in school A and 983 in school B). A detailed description of each school follows.

School A

According to NCES (2021), there were 1282 students in school A during the 2020-2021 school year. The racial makeup of the school included Caucasian (45.4%), Black (13%), Hispanic (37.2%), and Asian (0.5%) students. Also, there were students of two and more races (3.4%), Native Hawaiian/Pacific Islanders (0.2%), and Native American Indians (0.2%). The gender makeup of students at that time consisted of 47% female and 53% male students. Due to the number of students living in poverty (85%), the school received federal and state support as a Title I school.

School B

According to NCES (2021), there were 983 students in school B during the 2020-2021 school year. The racial makeup of the school included Caucasian (74.6%), Black (16.3%), Hispanic (3.8%), and Asian (0.2%) students. Also, there were students of two and more races (4.8%), Native Hawaiian/Pacific Islanders (0.2%), and Native American Indians (0.2%). The gender makeup of students consisted of 51% female and 49% male students. Due to the number

of students living in poverty (85.5%), the school received federal and state support as a Title I school.

Convenience or non-probability sampling is a method in which participants are non-randomly assigned to the treatment groups (Gall et al., 2007). Multiple researchers agreed that treatment groups formed with a convenience method may provide results with lesser validity than the use of randomization (Campbell & Stanley, 1963; Gall et al., 2007; Krishnan, 2018). To increase validity, the number of participants should exceed the required minimum for specific research designs (Gall et al., 2007). Determining the appropriate sample size is one of the ways to improve the validity of the study. The general rule is that the largest sample possible should be employed in the quantitative study. Gall et al. suggested having at least fifteen people in each group for casual-comparative and experimental research. Researchers should remember the importance of factors, such as attrition of participants, reliability of measures, and subgroup analysis. Gall et al. also emphasized the role of the close matching of subjects on the critical variables.

In the present study, the number of participants was 588. This number exceeded the required minimum of 126 participants for a medium effect size of 50 standard deviations with statistical power of .70 at the .05 alpha level and a $\beta = .30$ (Gall et al., 2007). The researcher conducted the sampling by collecting the official school records of all high school students who completed both semesters in the 2020-2021 school year and participated in the GA Milestones EOCT in Algebra I in the spring of 2021 at the research site. The sample consisted of 52% of males and 48% of females with a racial makeup of 71% White, 13% Black, 14% Hispanic, and 2% multi-racial students. Most participants attended the 9^{th} or 10^{th} grade because Algebra I is one of the first courses in high school mathematics. Several (N=13) students had to re-take the

previously failed Algebra I course, that is why they attended 11th or 12th grades. Among the 588 participants, there were 107 students with high incidence disabilities, including SLD, MID, OHI, and EBD.

Setting

During the 2020-2021 school year, due to the COVID-19 pandemic, 588 students in both high schools had an opportunity to choose between fully online and face-to-face educational settings for their first and second semesters. The online platform Odysseyware (Odysseyware, n.d.) delivered online instructions, while teachers in the face-to-face setting delivered their instructions in person. Both settings had aligned outlines and coursework but different delivery methods. Thus, asynchronous online lessons were mostly video based. In most lessons, short instructional videos (5-10 minutes each) were followed by practice assignments and summative assessments. The duration of the online and in-person lessons was approximately the same, that is 50 minutes of instructional time. The same teachers worked with both online and face-to-face learners. The main difference between the settings was the lack of direct contact with a teacher (except limited office hours for online support) and peers in the online setting. Also, assignments in both settings were similar but not identical. After the first semester, 25 online students decided to return to the face-to-face instructions for the second semester, while 24 students continued to receive online instruction. According to the district's policies, the switch from the face-to-face to online setting during the second semester was unavailable. After two semesters, the GA Milestones EOCT in the spring of 2021 concluded the course of Algebra I.

Students with and without disabilities participated in 0, 1, or 2 settings online. Thus, the researcher identified the following six groups of participants depending on their choice of educational settings for each of the two semesters and their disability status. The first group

consisted of 79 students with disabilities who received traditional face-to-face instructions during both semesters in the 2020-2021 school year (0 online semesters). The second group consisted of 13 students with disabilities who chose the online learning setting for the first semester only (1 online semester). The third group consisted of 15 students with disabilities who chose online learning setting for both semesters (2 online semesters). The fourth group consisted of 436 students without disabilities who received traditional face-to-face instructions during both semesters (0 online semesters). The fifth group consisted of 36 students without disabilities who chose online learning setting for the first semester only (1 online semester). The sixth group consisted of 9 students without disabilities who chose online learning setting for both semesters (2 online semesters). Gall et al. (2007) noted that uneven groups in sample size may affect the assumption of equal variances in an ANOVA test. See Table 1 for the number of participants in each of the six groups.

Table 1

Setting and Disability Status

Total Number of Participants (N=588)		**Educational Setting**		
		0 Face-to-Face/ 2 Online	1 Face-to-Face/ 1 Online	2 Face-to-Face/ 0 Online
Disability Status	Yes	15	13	79
	No	9	36	436
Total		24	49	515

Instrumentation

In the current research, the GA Milestones EOCT in Algebra I is the instrument used to measure the academic performance in math of high school students with and without disabilities.

The following section begins with a review of different methods of academic performance evaluation. Then, the history of the instrument's development supports its choice. Next, the researcher discusses the GA Milestones EOC tests' validity and reliability. After that, the analysis of the test structure clarifies its characteristic and appropriateness for the recent study. The discussion about the instrument's limitations concludes this section.

Evaluation of Academic Performance

According to Bandura (2001), academic performance is the extent to which individuals attain their educational goals. Sullivan (2010) defined academic achievement as the level of goal achievement, which can include both GPA and progress through stages on academic progress. In 2018, Kates et al. updated this definition by stating that academic achievement is any quantitative measure that demonstrates satisfactory performance or is perceived as such, including letter grades, test scores, acquired knowledge and skills, as well as self-reports of difficulty. Measuring academic achievement allows assessing a learner's progress in an academic program. Historically, scholars evaluated academic performance using various methods. Lister-Landman et al. (2017) suggested that academic functioning includes grades, school bonding, perceived scholastic competence, and other parameters that measure students' performance. Many scholars agreed that the grades that students earn in the classroom are a direct indicator of their academic achievement (Aaltonen et al., 2020; Lister-Landman et al., 2017; Lu et al., 2018). Other researchers used student information system data (such as GA Statewide Longitudinal Data System (SLDS) in Georgia) that include both demographic and grades for evaluating learning outcomes and perception (GA DOE, n.d.d; Joosten & Cusatis, 2020; Uzun & Kilis, 2019). Sullivan (2010) noted that attrition is generally an indication of an academic failure. Lu et

al. (2018) supported that statement and stated that the retention rate is more useful than GPAs for evaluation students' academic performance, especially in the online courses.

In an extensive meta-analysis of 39 studies from 14 countries and regions, Kates et al. (2018) found that researchers measure academic performance with GPAs, raw test scores, overall test scores, self-report of academic achievement, and performance on any research-constructed learning tasks and tests. As a result of this research, Kates et al. provided a more complete interpretation of academic achievement as "any measure that quantifies the extent to which a student is performing or feels he/she performing to a satisfactory level, including but not limited to letter grades and test scores, knowledge and skill acquisition, and self-reported measures of academic ability or difficulty" (p.1). Nevertheless, Aaltonen et al. (2020) argued that GPAs' validity and reliability are quite disputable since GPAs are not standardized. The same applies to various self-reports and surveys that provide researchers with subjective data influenced by extraneous and intrinsic factors (Gall et al., 2007).

In his works, Vygotsky (2017) maintained that researchers should not use standardized tests with non-mainstream population. Instead, he recommended using ZPD for instructions and assessments. Gershenson (2020) reported that over the past 20 years GPAs in the USA rapidly improved while SAT scores have remained stable or fallen. After comparing the course grades of a sample of 350,000 North Carolina students with their test scores in the state mandated standardized EOC assessment in Algebra I, Gershenson concluded that course grades became unreliable markers of knowledge and skills. He criticized the teachers who inflate grades to improve students' motivation and to avoid conflicts with parents and administration. Gershenson argued that students may fail to reach their full potential if they receive good grades without mastering the standards. On the contrary, students who received grades according to their real

achievements demonstrated better learning performance up to two years later after having a *tougher* teacher.

To increase the validity and reliability of the received data, private and public educational institutions often use standardized tests aiming to measure how well students acquire, learn, and accomplish the knowledge and skills set forth in a specific curriculum or unit. In Georgia, the Georgia Standards of Excellence (GSE) describe these academic skills and knowledge in each content area (GADOE, n.d. a; GADOE, 2016). Currently, public schools in Georgia use GA Milestones End-of-Grade (EOG) or End-of-Course (EOC) tests instead of the outdated Criterion-Referenced Competency Test (CRCT) (GADOE, n.d.b; GADOE, 2020a; GADOE, 2021c). The researcher chose the GA Milestones EOCT in Algebra I as the instrument in the present study.

The GA Milestones EOCT in Algebra I

The current study aims to examine if there is a significant statistical difference between the academic performance of high school students with and without disabilities in online and face-to-face educational settings. The researcher used the GA Milestones EOCT in Algebra I as the instrument to measure the academic performance of high school students in this study. Multiple research studies that have investigated related topics utilized this instrument (Forte et al., 2017; Halloran et al., 2021; Kim et al., 2008; NCES, 2021; Sass & Goldring, 2021). The purpose of the GA Milestones EOCT is to assess how well students have mastered the content standards in various academic areas (GADOE, 2021c). The state law mandates and regulates these tests in accordance with the Standards for Educational and Psychological Testing published by the American Educational Research Association (AERA, 2014). The instrument's assessment guide with sample items (GADOE, 2020b), as well as the test administration manual (GADOE, 2021c), can be found on the GA Department of Education website (gadoe.org).

Reliability and Validity of the Instrument

The specific methods used in the development of the GA Milestones EOC tests established their reliability and validity. Initially, multiple groups of educators from around the state formed committees to review and establish content standards, test specifications, content domain specifications, and test item specifications (GADOE, 2019). The GADOE published results of this work as the Georgia Milestones Assessment Guides (GADOE, 2021a). Qualified assessment specialists then wrote the tests items. Next, review committees analyzed the test items and recommended some of them for inclusion in the active standardized tests. After receiving the field tests results, the review committees accepted, revised, or rejected the items. Finally, the approved test items formed the actual tests in different subjects (GADOE, 2019).

Research studies (Forte et al., 2017; GA DOE, 2019) have confirmed the reliability of the GA Milestones EOCTs. The GA DOE commissioned a research group (Forte et al., 2017) to evaluate the alignment between the academic standards and the Georgia Milestones Assessment System's applicability for the state-mandated tests. The researchers reported that the Cronbach's alpha reliability coefficient (Cronbach, 1951) ranged from 0.88 to 0.94, depending on the subject area. The average Cronbach's alpha reliability coefficient for Algebra I was 0.91, for Biology it was 0.92, for US History it was 0.92, and for American Literature and Composition it was 0.89 (Forte et al., 2019; GA DOE, 2019). Thus, the reliability of the GA Milestones EOCT in Algebra I is acceptable for the present study.

The fact that the same teachers delivered both face-to-face and online instructions increased the validity of the instrument. During the 2020-2021 school year, teachers in the school district received two rosters, one for in-person students and one for online students. Online students worked independently with the Odysseyware coursework (Odysseyware, n.d.). They

had an opportunity to receive teacher's help as needed via email or during online support sessions on Mondays. Students in the face-to-face setting attended school four days a week (Tuesday through Friday). The school administration requested that teachers align online and face-to-face instructions. The Odysseyware coursework served as a base for educational content in all courses provided by the school district. These measures aimed to provide students with standardized instructions regardless of the educational setting. Thus, the validity of the instrument is sufficient for the current study. Probable limitations are analyzed in the discussion section of Chapter Five.

Permission to Utilize the Instrument

Since the GA Milestones EOCT is a state-mandated assessment, all students must participate in it to receive credit for Algebra I. Permission to use the instrument is not required from the participants or their caregivers (GADOE, 2021b; GADOE, 2021d). To take the test, students must be physically present in the school, even if they participated in the online educational setting.

Administration of the Instrument

In the spring of 2021, participants took the test on school-issued and monitored Chromebooks with the installed DCR INSIGHT Portal online assessment system (GADOE, n.d.c; GADOE, 2021d). Before taking the test, students had a practice session that allowed them to learn how to navigate the online assessment system and utilize online highlighters, calculators, graphing tools, and a reference sheet (GADOE, n.d.b; GADOE, n.d.c; GADOE, 2020a; GADOE, 2020b; GADOE2020c; GADOE, 2021a; GADOE, 2021c; GADOE, 2021d). Students with accommodations received them during online testing. The list of accommodations included small group and extended time for testing, text-to-speech assistance, and other adjustments that

matched students' needs listed in their individual education programs (IEPs) (GADOE, 2021c). The instrument's administration manual (GADOE, 2021c) and its secure practice directions (GADOE, 2020c) are located on the GA Department of Education website (gadoe.org).

Personnel

Prior to testing, the system test coordinators, the school test coordinators, and technical support coordinators provided training and supervision to the examiners and proctors. All testing personnel were certified Georgia educators (GADOE, n.d.b; GADOE, n.d.c; GADOE, 2020a; GADOE, 2020b; GADOE, 2021a; GADOE, 2021 c; GADOE, 2021d). The examiners and proctors did not have access to the testing items before, during, or after testing. During the test administration, testing personnel constantly circulated around the testing sites, supervising the students, and calling for technical assistance when necessary (GADOE, 2020b; GADOE, 2021c).

The Instrument Questions and Allotted Time

The testing questions covered four domains: Equations (30% of a final score), Expressions (20%), Functions (35%), and Algebra Connection to Statistics and Probability (15% of the final score). The questions were presented in selected-response and technology enhanced items formats, such as keypad input, drop down, multiple-select, among others. The test consisted of 55 questions divided into two sections. Both sections were administered on the same day, with a short break of up to 10 minutes between them (GADOE, 2020b; GADOE, 2021c). Each section lasted from 45 to 65 minutes, with a total time of approximately 150 minutes, including material distribution and collection, technical support, and the break. Students with the extended time accommodations had the opportunity to work for a longer period as outlined in their IEPs (GADOE, 2021c).

Scoring Procedures

The online Georgia Milestones Assessment System (The DRC INSIGHT Portal) scored the EOCT for all participants (GADOE, n.d.c; GADOE, 2021a; GADOE, 2021c). The scoring process involved raw scores ranging from 200 to 785, conversion to derived Grade Conversion Scores (GCS) ranging from 0 to 100, calculation of the Standard Error of Measurement (SEM) for each student, determination of Criterion-Referenced and Norm-Referenced Scores, as well as identification of mastery levels in each domain and content area (GADOE, 2021a). The test reports included individual reports for each content area and domain, group reports sorted by class and disability status, as well as school reports, school system reports, and state reports for each content area and group (GADOE, 2021a; GADOE, 2021c; GADOE, 2021d). In this study, the researcher used the individual and group reports for the Algebra I content area from both high schools in the school district.

Procedures

The following section describes the procedures for conducting the present study. The process of securing the Institutional Review Board's (IRB) approval is outlined. After that, the gathering data methods are specified. The school district permission and any other pertinent information are discussed next. The methods of protection for the anonymity of participants conclude the section.

Permissions

The researcher applied for the IRB approval of the study and the school district's permission to access the school records. Since the study did not use identifiable information, such as students' names and their individual numbers, the assent and consent forms were not required (see Appendix A for IRB Approval). After receiving the IRB approval and the school

district superintendent's permission (see Appendix B for School District Permission), the researcher contacted the instructional data specialists in both schools, asking them to provide the school records that are stripped of any personal data, such as participants' names, social security numbers, and addresses.

Collecting Data

The researcher accessed the United States Census Bureau website to collect the demographic information about the county and its general population (USCB, n.d.). In addition, the researcher used the data from NCES (n.d.), GOSA (2019), and GA SLDS (GADOE, n.d.) to gather and analyze demographics, such as gender, age, race, and disability status of students in the school district. After the school district granted permission to access school records, the researcher identified students who received instructions online or face-to-face instruction during the first and second semesters of the 2020-2021 school year. The researcher then accessed the participants' GA Milestones EOCT scores in Algebra I. These scores represented the students' academic performance in mathematics. To ensure the anonymity of participants, the school district's instructional data specialists removed all identifying information and replaced participants' names with numbers.

Securing Data

Throughout the data collection process, all information that could identify the participants was protected. Data was securely stored, and only the researcher had access to the records. The data was stored on a password protected computer and a password protected external hard drive. When not in use, the external drive was stored in a locked filing cabinet. The data will be retained for a period of five years after the completion of this research study.

Data Analysis

The researcher used a two-way analysis of variance (ANOVA) for data analysis in the present study. Gall et al. (2007) recommended using a two-way (or factorial) ANOVA when there are two independent variables. The main goal of a two-way ANOVA is to compare multiple groups of two factors (i.e., independent variables) and determine their effect on a continuous outcome (i.e., dependent variable) (Warner, 2013). Warner noted that a two-way ANOVA is a data analysis tool in both experimental and non-experimental research studies. Since in this study each participant contributed a score in only one cell, this research used a between-subject (between-S) design.

In this study, the two categorical independent variables were the educational setting and students' disability status. The educational setting consisted of three groups because students chose among three instructional delivery methods. The first group had online instructions during both semesters. The second group had the online setting during the first semester and the face-to-face instructions during the second semester. The third group of students received face-to-face instructions during both semesters. The second independent variable (i.e., disability status) had two categories since it involves students with and without disabilities. See Table 1 for a description of the groups. The total number of participants was 588, which exceeds the required minimum of 126 when assuming a medium sample size with statistical power of .7 at the .05 alpha level (Gall et al., 2007). See Table 2 for descriptive statistics.

The researcher used the SPSS (Statistical Package for the Social Sciences) software for data analysis. Warner (2013) stated that the equal number of participants in each group provides the maximum power and simplifies the analysis in the experimental studies. However, the current study is a non-experimental ex post facto causal- comparative research with various

numbers of participants in each group. In such cases, Warner suggested using additional statistical methods to identify how much variance is predictable. The assumptions of a two-way ANOVA include the identification of outliers, the assumption of normality, and the assumption of equal variance (Green & Zalkind, 2017; Warner, 2013).

The researcher conducted data screening, looking for data errors and inconsistencies, as well as scanned for extreme outliers by using a box-and-whisker plot for each group and variable. The ANOVA requires that the assumption of normality be met (Green & Zalkind, 2017; Warner, 2013). Since the sample size was greater than 50 participants, the researcher used the Kolmogorov-Smirnov test for testing the assumption of normality. The 95% confidence level was the aim for these statistical tests. Effect size was tested with partial eta square. The researcher tested the assumption of homogeneity of variance-covariance matrices in SPSS with the Levene's test of Homogeneity of Variance.

A two-way ANOVA provided three significance tests, namely, the main effect of disability status, the main effect of educational setting, and a test of the interaction between both factors. Each of the significance tests examined one of the three null hypotheses (Warner, 2013). According to Warner, "simple η^2 effect-size estimates can be computed either from the sums of squares or from the *F* ratio and its degrees of freedom" (p. 517). The graph analysis helps to test the final hypothesis about the interaction of both factors. The parallel lines on that graph demonstrate if there is any interaction between the two factors. If these lines are not parallel, there is some level of interaction (Green & Zalkind, 2017; Warner, 2013).

The null hypotheses should be rejected if there is a 95% confidence level with the alpha level set at $p < .05$ (Warner, 2013). Consequently, the researcher performed post hoc analysis, that is, a Tukey test. The goal of this step was to compare all possible pairs of group means.

Additionally, a follow-up analysis of simple main effects allowed the researcher to compare mean symptoms between the groups and identify the location of differences within the groups (Green & Zalkind, 2017; Warner, 2013).

To summarize, a quasi-experimental causal-comparison design has several limitations that negatively affect its validity. Among them are the lack of randomization of the sample and the absence of a pretest for participants. To overcome these limitations, the researcher used a large sample size. The researcher also implemented causal comparison due to the nature of data, which consisted of scores in the mathematics standardized test. These discrete and countable values ranging from 200 to 785 presented a dependent variable. The type of educational setting and students' disability status worked as the two independent categorical variables for this quasi-experimental comparison study. A two-way analysis of variance (ANOVA) was used to identify and investigate the difference among the academic performance of high school students with and without disabilities in the online and face-to-face educational settings.

CHAPTER FOUR: FINDINGS

Overview

The purpose of this quantitative, non-experimental causal-comparative study was to determine if there is a statistically significant difference in the academic performance of high school students with and without disabilities who receive math instruction in face-to-face and online educational settings. The two independent variables in the current research were the students' choice of educational setting and their disability status. The only dependent variable was the students' scores for the state-mandated GA Milestones EOCT in Algebra I. To examine the three null hypotheses, the researcher used a two-way ANOVA followed by the Welch and Brown-Forsythe Robust Tests of Equality of Means, and a post hoc Tukey test. The following chapter includes the research question, three null hypotheses, data screening procedures, descriptive statistics, assumption testing, and results.

Research Question

The research question for this study was:

RQ: Is there a significant difference in Algebra I skills among high school students based on their disability status and educational setting, taking 0, 1, or 2 semesters online?

Hypotheses

The null hypotheses for this study were:

$H_0$1: There is no statistically significant difference between the Algebra I skills in high school students with and without disabilities, as measured by the Georgia Milestones End-of-Course test scores.

$H_0$2: There is no statistically significant difference among the Algebra I skills in high school students taking 0, 1, or 2 semesters online, based on their educational setting, as measured by the Georgia Milestones End-of-Course test scores.

$H_0$3: There is no statistically significant interaction between the high school students' status of disability and their educational setting (taking 0, 1, or 2 semesters online), as measured by the Georgia Milestones End-of-Course test scores in Algebra I.

Descriptive Statistics

Descriptive statistics examined the dependent variable for each group of students. Descriptive statistics are found in Table 2.

Table 2

Descriptive Statistics

Dependent Variable: EOC Score

Semesters Online	Disability Status	*M*	*SD*	*n*
0	no SWD	480.05	41.183	436
	SWD	435.15	25.077	79
	Total	473.17	42.345	515
1	no SWD	453.50	35.178	36
	SWD	418.38	31.474	13
	Total	444.18	37.354	49
2	no SWD	435.56	21.090	9
	SWD	428.40	39.554	15
	Total	431.08	33.460	24
Total	no SWD	477.23	41.433	481
	SWD	432.17	28.521	107
	Total	469.03	43.052	588

The sample consisted of 588 participants who took the GA Milestones End-of-Course (EOCT) Algebra I test in the spring of 2021. There were 481 students without disabilities (*M*=477.23, *SD*=41.433) and 107 students with disabilities (*M*=432.17, *SD*=28.521). During the 2020-2021 school year, all students had an opportunity to take 0, 1, or 2 semesters online in their Algebra I class. Consequently, there were six groups of participants. That is, students without disabilities, who took 0 semesters online (*n*=436, *M*=480.05, *SD*=41.183), 1 semester online (*n*=36, *M*=453.50, *SD*=35.178), or 2 semesters online (*n*=9, *M*=435.56, *SD*=21.090). There were also students with disabilities who took 0 semesters online (*n*=79, *M*=435.15, *SD*=25.077), 1 semester online (*n*=13, *M*=418.38, *SD*=31.474), or 2 semesters online (*n*=15, *M*=428.40, *SD*=39.554). Table 3 presents the estimated marginal means for these six groups.

Table 3

Estimated Marginal Means

			95% Confidence Interval	
Semesters Online	Disability Status	Std. Error	Lower Bound	Upper Bound
0	no SWD	1.849	476.421	483.684
	SWD	4.344	426.621	443.683
1	no SWD	6.434	440.862	466.138
	SWD	10.708	397.354	439.415
2	no SWD	12.869	410.280	460.831
	SWD	9.968	408.822	447.978

See Figures 1 and 2 for the Estimate Marginal Means plots.

Figure 1

Estimated Marginal Means of EOCT Scores (Disability Status/Semesters Online)

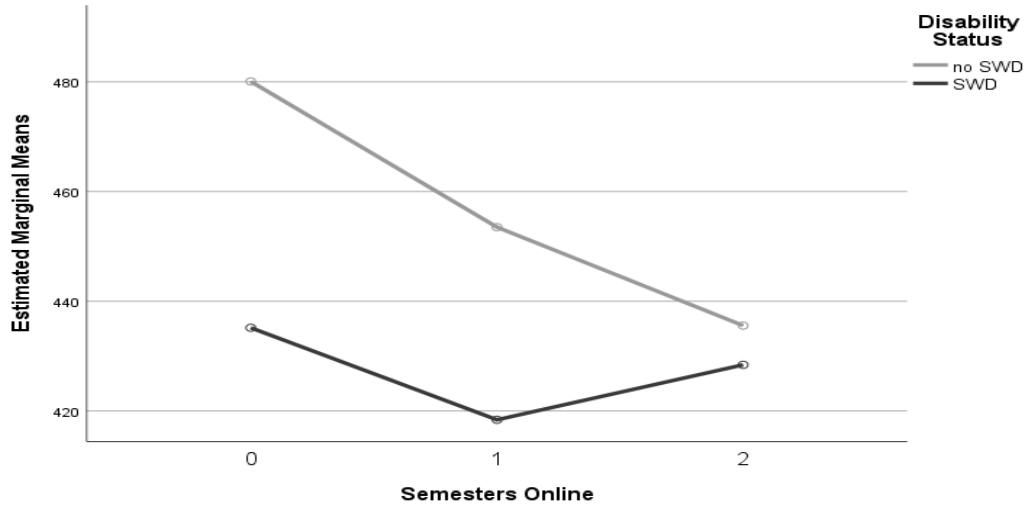
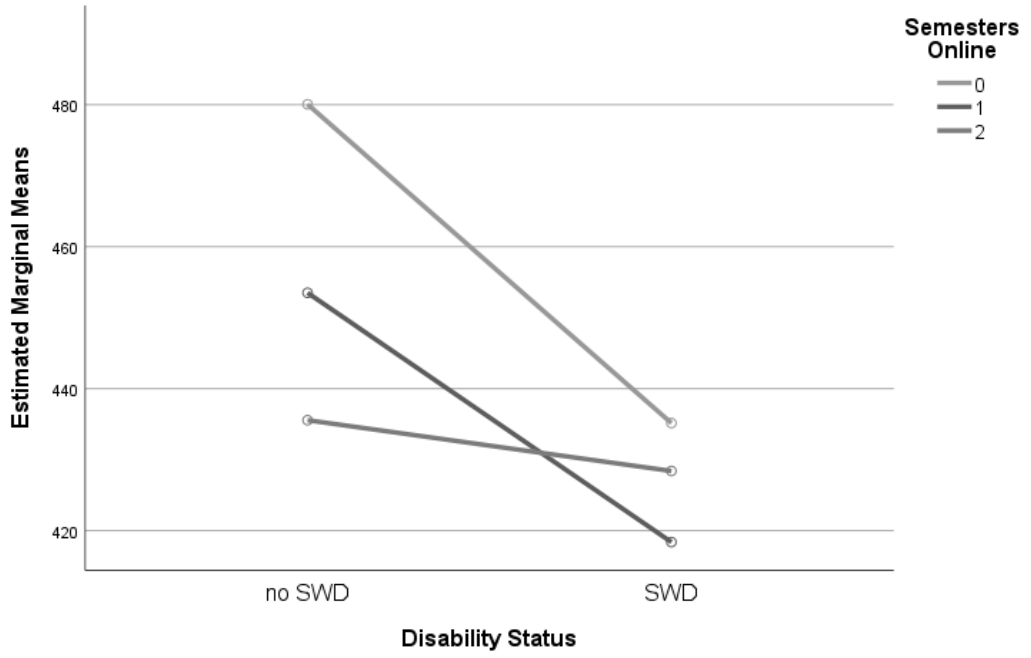


Figure 2

Estimated Marginal Means of EOCT Scores (Semesters Online/ Disability Status)



Results

Null Hypothesis One: EOCT Scores and Disability Status

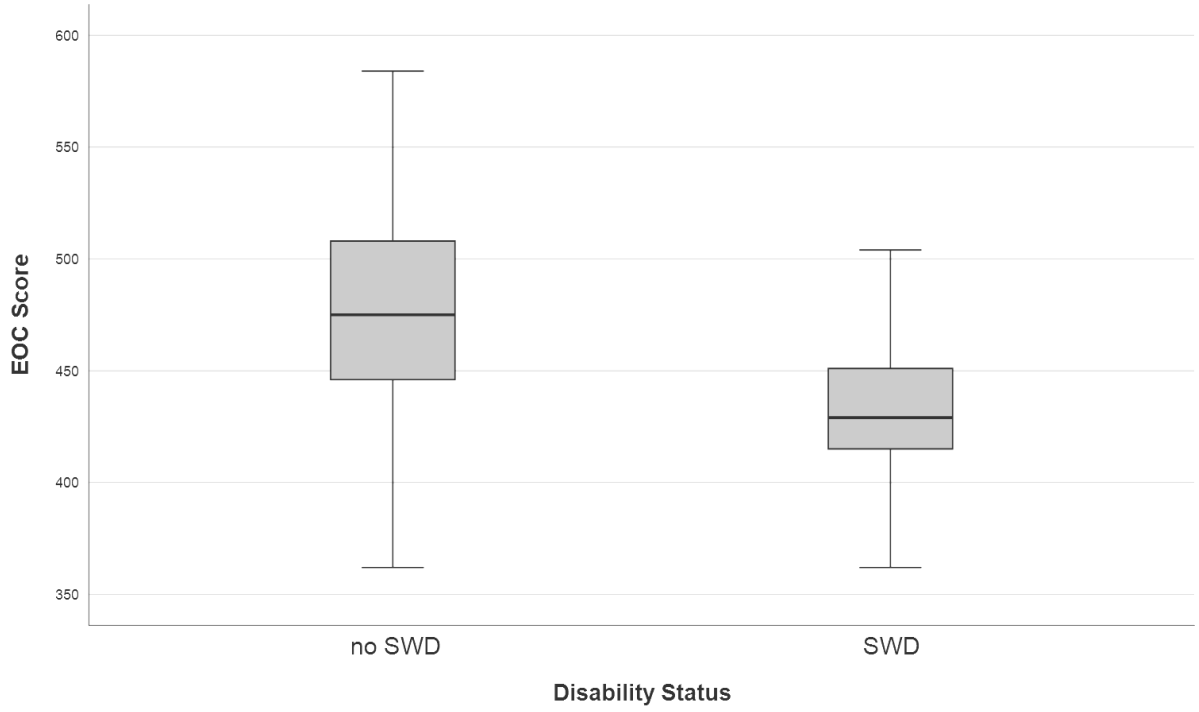
$H_0$1: There is no statistically significant difference between the Algebra I skills in high school students with and without disabilities, as measured by the Georgia Milestones End-of-Course test scores.

Data Screening

Data screening was conducted on each group's dependent variable. The researcher scanned for data entry errors and inconsistencies. No data errors or inconsistencies were identified. Box and whiskers plots were used to detect outliers in the dependent variable. No extreme outliers were identified. See Figure 3 for box and whisker plot of Disability Status/EOCT Scores.

Figure 3

Box and Whisker Plot (Disability Status/EOCT Scores)



Assumption Testing

A two-way ANOVA was used to test the null hypothesis. The ANOVA requires that the assumption of normality and the homogeneity of variance are met (Warner, 2013).

Assumption of Normality. To meet the assumption of normality, the significance value should be greater than p=0.05. The researcher examined normality with the Kolmogorov-Smirnov test because the sample size was greater than 50 participants. The assumption of normality was partially met. Thus, the disability status had $p = .05$ for SWD and $p < .001$ for students without disabilities. Multiple authors (Glass & Hopkins, 1996; Howell, 2008; Lakens & Caldwell, 2021; Lynch et al., 2019; Sheng, 2008; Warner, 2013) maintained that ANOVA is sufficiently robust against violations of the normality assumptions. Consequently, the Type 1 error rate remains close to the alpha level specified in the test, especially with a large sample size. Therefore, the researcher conducted a two-way ANOVA, disregarding the failed normality tests for the groups of students without disabilities. Nevertheless, the limitations of the study section addressed the lack of a normal distribution in these groups of participants. See Table 4 for Tests of Normality for Disability Status/EOCT Scores.

Table 4

Tests of Normality for Disability Status/EOCT Scores

	Disability Status	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	*df*	Sig.	Statistic	*df*	Sig.
EOCT Score	no SWD	.068	481	<.001	.992	481	.009
	SWD	.086	107	.050	.986	107	.301

a. Lilliefors Significance Correction

Assumption of Homogeneity of Variance. The ANOVA requires that the assumption of homogeneity of variance be met. To meet this assumption, the significance value should be

greater than p=0.05. The researcher used Levene's test to examine the assumption of homogeneity of variance. The assumption of homogeneity of variance failed with p <.001 for EOCT Scores/Disability Status relationships. The fact that the homogeneity assumption was not met for the Disability Status/EOCT Scores conditioned another limitation of the study, which is discussed in Chapter Five of this manuscript. See Tables 5 for Levene's test of Equality of Error Variance for Disability Status/ EOCT Scores.

Table 5

Levene's test of Equality of Error Variance for Disability Status/ EOCT Scores

		Levene Statistic	*df1*	*df2*	Sig.
EOCT Score	Based on Mean	23.219	1	586	<.001
	Based on Median	22.469	1	586	<.001
	Based on Median and with adjusted *df*	22.469	1	565.223	<.001
	Based on trimmed mean	23.189	1	586	<.001

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.[a,b]

a. Dependent variable: EOCT Score
b. Design: Intercept + SWD

Multiple authors (Glass & Hopkins, 1996; Howell, 2008; Lakens & Caldwell, 2021; Lynch et al., 2019; Sheng, 2008; Warner, 2013) agreed that the failed homogeneity assumption possesses a greater risk for a study than the failed assumption of normality. They recommended several methods to overcome this issue, transforming the data with a base of a logarithm, taking the square root of a dependent value score, among others (Warner, 2013). Researchers also suggested the special software simulations (Caldwell, 2023), applications of the conservative F-test (Glass & Hopkins, 1996), the Brown-Forsythe test (1995), the Welsch test (Grande, 2016),

and other methods. To mitigate the potential negative effects of the failed homogeneity assumption, the researcher conducted the two latter tests as follows.

Robust Tests of Equality of Means

Kirk (1995) suggested using the Brown-Forsythe test when sample sizes are unequal, as this test is robust to non-normality. It utilizes the F-test on the absolute value of the deviation scores using the median instead of the mean. Therefore, it is less influenced by groups with larger score ranges. Grande (2016) supported this suggestion and added that the Welch test also works with uneven groups but provides more accurate results. In this study, the Brown-Forsyth and the Welch tests' results supported the findings of a two-way ANOVA, as their significance levels were $p<0.001$. See Table 6 for Robust Tests of Equality of Means in the Disability Status/ EOCT Scores relationships.

Table 6

Robust Tests of Equality of Means (Disability Status/EOCT Scores)

Disability Status/EOCT Score				
	Statistic[a]	*df1*	*df2*	Sig.
Welch	181.787	1	218.262	<.001
Brown-Forsythe	181.787	1	218.262	<.001

a. Asymptotically F distributed.

Results for Null Hypothesis One ($H_0 1$)

The researcher rejected the first null hypothesis, which states that there is no statistically significant difference between the GA Milestones EOCT scores in Algebra I in high school students with and without disabilities, at the 95% confidence level. The F-value was F (1, 582) = 17.141 with $p<0.001$. The partial eta square was $\eta^2_{part} = .029$, indicating a medium size effect.

There was a statistical difference in the EOC scores among students with and without disabilities.

Null Hypothesis Two: EOCT Scores and Online Setting

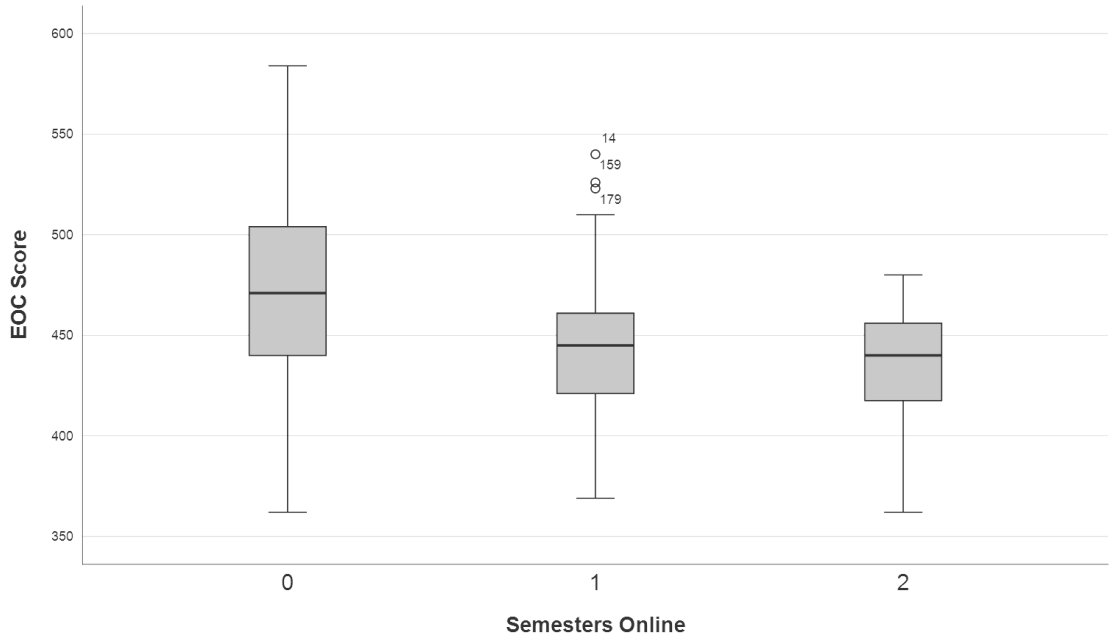
$H_0$2: There is no statistically significant difference among the Algebra I skills in high school students taking 0, 1, or 2 semesters online, based on their educational setting, as measured by the Georgia Milestones End-of-Course test scores.

Data Screening

Data screening was conducted on each group's dependent variable. The researcher scanned for data entry errors and inconsistencies. No data errors or inconsistencies were identified. Box and whiskers plots were used to detect outliers in the dependent variable. There were three outliers on the second plot that demonstrated outliers on the EOC scores dependent on the number of semesters online. These were three students without disabilities who had one online semester and demonstrated relatively high EOCT scores. Warner (2013) suggested several ways of reducing the impact of outliers. The methods include the preliminary conditions for the range of acceptable scores, removal of the extremes completely, their nonlinear transformation (i.e., taking the base 10 logarithm of the original data), or winsorizing (that is, replacing the most extreme scores with the next highest score). Warner reminded researchers that they must make reasonable judgment calls about the ways of handling extreme scores or outliers. In the current study, the researcher decided to keep the outliers since they were not extreme. However, the limitations section of the manuscript will address this issue. See Figure 4 for box and whisker plot Semesters Online/EOCT Scores.

Figure 4

Box and Whisker Plot (Semesters Online/EOCT Scores)



Assumptions

The ANOVA requires that the assumptions of normality and the homogeneity of variance were met. Otherwise, the researcher must mediate their violations (Warner, 2013).

Assumption of normality. To meet the assumption of normality, the significance value should be greater than p=0.05. The researcher examined normality with the Kolmogorov-Smirnov test because the sample size was greater than 50 participants. The assumption of normality was partially met. Thus, the number of online semesters had p <.001 for 0 semesters, p =.200 for 1 semester, and p =.196 for 2 semesters. Since the ANOVA is sufficiently robust against violations of the normality assumptions (Glass & Hopkins, 1996; Howell, 2008; Lakens & Caldwell, 2021; Lynch et al., 2019; Sheng, 2008; Warner, 2013), the researcher conducted a two-way ANOVA. However, the limitations of the study section addressed the lack of a normal

distribution in these groups of participants. See Table 7 for Tests of Normality for Semesters Online/EOCT Scores.

Table 7

Tests of Normality for Semesters Online /EOCT Scores

	Semesters Online	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	*df*	Sig.	Statistic	*df*	Sig.
EOCT Score	0	.066	515	<.001	.989	515	<.001
	1	.102	49	.200*	.976	49	.411
	2	.147	24	.196	.927	24	.082

*. This is a lower bound of the true significance.

Assumption of Homogeneity of Variance. The ANOVA requires that the assumption of homogeneity of variance be met. To meet this assumption, the significance value should be greater than p=0.05. The researcher used Levene's test to examine the assumption of homogeneity of variance. The assumption of homogeneity of variance was met with p =0.052 for Semesters Online/ EOCT Scores. See table 8 for Levene's test of Equality of Error Variance for Semesters Online/ EOCT Scores.

Table 8

Levene's test of Equality of Error Variance for Semesters Online/ EOCT Scores

		Levene Statistic	*df1*	*df2*	Sig.
EOCT Score	Based on Mean	2.963	2	585	.052
	Based on Median	3.100	2	585	.046
	Based on Median and with adjusted df	3.100	2	584.728	.046
	Based on trimmed mean	2.986	2	585	.051

Robust Tests of Equality of Means

Both the Brown-Forsyth and the Welch parametric tests' results demonstrated the significance levels of $p<0.001$. See Table 9 for Robust Tests of Equality of Means in the Semesters Online/ EOCT Scores relationships.

Table 9

Robust Tests of Equality of Means

Semesters Online/EOCT Score				
	Statistic[a]	*df1*	*df2*	Sig.
Welch	27.983	2	48.422	<.001
Brown-Forsythe	28.582	2	78.671	<.001

a. Asymptotically F distributed.

Results for Null Hypothesis Two ($H_0 2$)

The researcher rejected the second null hypothesis, which stated that there is no statistically significant difference among the GA Milestones EOCT scores in Algebra I in high school students based on educational setting, taking 0, 1, or 2 semesters online, at the 95% confidence level. The F-value was (2, 582) = 8.954 with $p<0.001$. The partial eta square was $\eta^2_{part} = .03$, indicating a medium size effect. There was a statistical difference in the EOCT scores among students who had 0, 1, or 2 semesters online.

Tukey Post Hoc Analysis

Since the researcher rejected two first null hypotheses, post hoc analysis was conducted. However, the analysis focused solely on the second null hypothesis, which examined the groups based on the number of semesters online. This was due to the requirement of having three levels in the independent variable for a post hoc. In this case, the independent variable had three levels, namely, 0, 1, or 2 semesters online. The researcher performed the Tukey test to compare all

possible pairs of group means. The Tukey test revealed significant mean differences (p less than =.05) between the scores of students who took 0 and 1 semesters online with p <.001), as well as between the scores of students who took 0 and 2 online semesters (*p* <.001). However, there was no statistically significant difference between the groups of students who took 1 and 2 online semesters (p=.362). See Table 10 for pairwise comparisons.

Table 10

Multiple Comparisons

Dependent Variable: EOCT Score

Tukey HSD

(I) Semesters Online	(J) Semesters Online	Mean Difference (I-J)			95% Confidence Interval	
			Std. Error	Sig.	Lower Bound	Upper Bound
0	1	28.98*	5.772	<.001	15.42	42.54
	2	42.08*	8.062	<.001	23.14	61.03
1	0	-28.98*	5.772	<.001	-42.54	-15.42
	2	13.10	9.619	.362	-9.50	35.70
2	0	-42.08*	8.062	<.001	-61.03	-23.14
	1	-13.10	9.619	.362	-35.70	9.50

Null Hypothesis Three: EOCT Scores and Two Factors

$H_0$3: There is no statistically significant interaction between the high school students' status of disability and their educational setting (taking 0, 1, or 2 semesters online), as measured by the Georgia Milestones End-of-Course test scores in Algebra I.

Data Screening

Data screening was conducted on each group's dependent variable. The researcher scanned for data entry errors and inconsistencies. No data errors or inconsistencies were identified.

Assumptions

The ANOVA requires that the assumptions of normality and the homogeneity of variance were met (Warner, 2013).

Assumption of normality. To meet the assumption of normality, the significance value should be greater than p=0.05. The researcher examined normality with the Kolmogorov-Smirnov test because the sample size was greater than 50 participants. The assumption of normality was partially met for both independent variables. Thus, the number of online semesters had p <.001 for 0 semesters, p =.200 for 1 semester, and p =.196 for 2 semesters. Also, the disability status had p = .05 for SWD and p <.001 for students without disabilities. However, the ANOVA is robust against violations of the normality assumptions, especially with a large sample size (Glass & Hopkins, 1996; Howell, 2008; Lakens & Caldwell, 2021; Lynch et al., 2019; Sheng, 2008; Warner, 2013). Therefore, the researcher conducted a two-way ANOVA, disregarding the failed normality tests for the groups of students without disabilities and students with 0 semesters online. These limitations of the study are addressed in Chapter Five of the manuscript. See Tables 4 and 6 for Tests of Normality for Disability Status/ EOCT Scores and Test of Normality for Semesters Online/EOCT Scores.

Assumption of Homogeneity of Variance. The ANOVA requires that the assumption of homogeneity of variance be met. To meet this assumption, the significance value should be greater than p =0.05. The researcher used Levene's test to examine the assumption of

homogeneity of variance. The assumption of homogeneity of variance was met with p =0.052 for EOCT/Semesters Online and failed with p <.001 for EOCT Scores/Disability Status relationships. The fact that the homogeneity assumption was not met for the EOCT Scores/Disability Status groups conditioned another limitation of the study, which is discussed in Chapter Five of this manuscript. See Table 11for Levene's test of Equality of Error Variance for Semesters Online/Disability Status/EOCT Scores relationships.

Table 11

Levene's test of Equality of Error Variance for Semesters Online/Disability Status/EOCT Scores/

		Levene Statistic	*df1*	*df2*	Sig.
EOCT Score	Based on Mean	6.807	5	582	<.001
	Based on Median	6.880	5	582	<.001
	Based on Median and with adjusted df	6.880	5	551.558	<.001
	Based on trimmed mean	6.842	5	582	<.001

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.[a,b]

a. Dependent variable: EOCT Score

Two-way ANOVA

The researcher used a two-way ANOVA to examine whether there was a difference between the GA Milestones EOCT scores in Algebra I for students with and without disabilities who took 0, 1, or 2 semesters of Algebra I online. The two independent variables were the number of semesters online and students' disability status. The dependent value was the participants' EOCT scores. See Table 12 for Tests of Between-Subjects Effects.

Table 12

Tests of Between-Subjects Effects

Dependent Variable: EOCT Score

Source	Type III Sum of Squares	*df*	Mean Square	*F*	Sig.	Partial Eta Squared
Corrected Model	220518.523[a]	5	44103.705	29.590	<.001	.203
Intercept	23629184.316	1	23629184.316	15853.214	<.001	.965
SWD	25548.567	1	25548.567	17.141	<.001	.029
Semesters Online	26691.536	2	13345.768	8.954	<.001	.030
SWD * Semesters Online	7789.092	2	3894.546	2.613	.074	.009
Error	867469.863	582	1490.498			
Total	130442879.000	588				
Corrected Total	1087988.386	587				

R Squared = .203 (Adjusted R Squared = .196)

Robust Test/SPSS for HC0

Since SPSS does not allow for the Brown-Forsythe and Welch robust tests in a two-way ANOVA, the researcher utilized the SPSS HC0 robust test. This test relies on the original asymptotic or large sample robust, empirical estimator of the covariance matrix of the parameter estimates (Green & Zalkind, 2017). The results of this robust test were consistent with the findings of a two-way ANOVA, which failed to reject the third null hypothesis. The third null hypothesis stated that is no statistically significant interaction between the GA Milestones EOCT

scores in Algebra I for high school students based on their status of disability and educational setting. See Table 13 for the robust test results.

Table 13

Parameter Estimates with Robust Standard Errors (HC0)

Dependent Variable: EOCT Score

					95% Confidence Interval	
Parameter	B	Robust Std. Error[a]	t	Sig.	Lower Bound	Upper Bound
Intercept	428.400	9.867	43.419	<.001	409.022	447.778
[SWD=0]	7.156	11.886	.602	.547	-16.189	30.500
[SWD=1]	0[b]	.	.	.	.	.
[SemestersOnline=0]	6.752	10.257	.658	.511	-13.394	26.897
[SemestersOnline=1]	-10.015	12.949	-.773	.440	-35.449	15.418
[SemestersOnline=2]	0[b]	.	.	.	.	.
[SWD=0] * [SemestersOnline=0]	37.745	12.370	3.051	.002	13.450	62.041
[SWD=0] * [SemestersOnline=1]	27.960	15.654	1.786	.075	-2.785	58.704
[SWD=0] * [SemestersOnline=2]	0[b]	.	.	.	.	.
[SWD=1] * [SemestersOnline=0]	0[b]	.	.	.	.	.
[SWD=1] * [SemestersOnline=1]	0[b]	.	.	.	.	.
[SWD=1] * [SemestersOnline=2]	0[b]	.	.	.	.	.

a. HC0 method

a. This parameter is set to zero because it is redundant.

Results for Null Hypothesis Three ($H_0$3)

The researcher failed to reject the third null hypothesis, which stated that there is no statistically significant interaction between the GA Milestones EOCT scores in Algebra I among high school students based on their status of disability and educational setting, taking 0, 1, or 2 semesters online, at the 95% confidence level. The F-value was F (2, 582) = 17.141 with p = .074. The partial eta square was η^2_{part} = .009. The effect size in this case was small. According to these results, there was not an interaction effect between students' EOCT scores based on the combination of their status of disability and educational setting.

To summarize, the first null hypothesis investigated the main effect of disability on the GA Milestones EOCT scores in Algebra I. The second null hypothesis examined the main effect of educational setting on these scores. Finally, the third null hypothesis analyzed the interaction effect of the two variables, namely, disability status and educational setting. The researcher conducted a two-way ANOVA to answer the research question. Since the six groups had different numbers of participants (i.e., were unbalanced), the homogeneity assumption was only partially met. Therefore, the researcher conducted three parametric tests to address this issue, namely the Brown-Forsythe and the Welsch tests for the first two null hypotheses and the SPSS Robust HC0 test for the third null hypothesis.

After conducting a two-way ANOVA data analysis, followed by Brown-Forsythe and Welch robust tests, the researcher rejected the first null hypothesis, which stated that there is no statistically significant difference between the GA Milestones EOCT scores in Algebra I for high school students with and without disabilities. The current study demonstrated that there was a significant difference in the EOCT scores between these two groups. According to the ANOVA findings, SWD received significantly lower EOCT scores compared with students without

disabilities. The researcher also rejected the second null hypothesis, which stated that there is no statistically significant difference among the GA Milestones EOCT scores in Algebra I for high school students based on the number of semesters taken online. The data analysis indicated that there was a significant difference in the EOCT scores that correlated with the number of online semesters. The post hoc test revealed that both 1 and 2 online semesters had a negative impact on the EOCT scores. However, the researcher failed to reject the third null hypothesis, which stated that there is significant interaction between the GA Milestones EOCT scores in Algebra I for high school students based on their disability status and the number of semesters taken online. These findings were supported by the HC0 parametric robust test for heterogeneous variances. It appears that two independent variables (i.e., disability status and semesters online) did not have an impact on each other in this study. The study findings, implications, limitations, and suggestions for future research are discussed in the concluding chapter of the manuscript.

CHAPTER FIVE: CONCLUSION

Overview

The following chapter provides a summary of the key research findings. In the discussion section, the researcher reminds the readers about the purpose of the study and its research question. After that, the researcher reviews each of the three hypotheses in relation to the research results and their implications. Next, the chapter identifies and addresses several limitations of the study. The opportunities and suggestions for future research conclude the chapter.

Discussion

The purpose of this quantitative, non-experimental causal-comparative study was to examine whether there is a statistically significant difference in the academic performance of high school students with and without disabilities who receive math instruction in face-to-face and online educational settings. The study utilized the GA Milestones EOCT scores in Algebra I as the measure of academic performance. The convenience sample consisted of 588 high school students attending 9th through 12th grades in two public Title I schools within a rural North Georgia school district. These students completed two semesters of Algebra I in different educational settings during the 2020-2021 school year and subsequently participated in the GA Milestones EOCT for Algebra I in the spring of 2021.

The study involved two independent variables, namely students' choice of educational setting and their disability status. According to Lemons et al. (2018), educational setting is the method of delivery and context in which students receive instruction. In this study, a face-to-face setting referred to in-person instruction delivered by a teacher (Lemons et al., 2018; Wise, 2019), while in an online educational setting students receive all instructions via ICT (Wise, 2019).

Disability status was based on participants' eligibility for special education services under at least one disability category (IDEA, 2004).

In this study, participants had the option to choose between online and face-to-face settings for each of the two semesters in the 2020-2021 school year. Therefore, there were three possibilities: (a) 0 semesters in the online setting, (b) 1 semester in the online setting, and (c) 2 semesters in the online setting. To identify students with and without disabilities, the researcher marked their disability status with either *yes* or *no*. Consequently, participants formed six groups based on their choice of educational setting and their disability status.

The dependent variable in this study was the students' scores for the state-mandated GA Milestones EOCT in Algebra I. This exam assesses high school students' academic performance in mathematics. Bandura (2001) defined academic achievement or performance as the extent to which individuals attained their educational goals. The scores were presented as discrete and countable values ranging from 200 to 785, where decimal scores were unavailable.

The research question for this study was:

RQ: Is there a significant difference in Algebra I skills among high school students based on their disability status and educational setting, taking 0, 1, or 2 semesters online?

Based on this research question, the researcher formulated three null hypotheses. The first null hypothesis investigated the main effect of disability on the GA Milestones EOCT scores in Algebra I. The second null hypothesis examined the main effect of educational setting on these scores. Finally, the third null hypothesis analyzed the interaction effect of the two variables, namely, disability status and educational setting. The following section summarizes the results of the present study and compares them with previously published theoretical and practical findings in the relevant areas.

Null Hypothesis One: EOCT Scores and Disability Status

$H_0$1: There is no statistically significant difference between the Algebra I skills in high school students with and without disabilities, as measured by the Georgia Milestones End-of-Course test scores.

After conducting a two-way ANOVA data analysis, the researcher rejected the first null hypothesis. The findings of the present study indicated a significant difference in the EOCT scores between these two groups. According to the study, students with disabilities received significantly lower EOCT scores (M=432.17, SD=28.521) compared to students without disabilities (M=477.23, SD=41.433). These findings aligned with the existing literature, in which multiple researchers reported a significant disproportionality in mathematical performance between students with and without disabilities (Bone et al., 2021; Hughes et al., 2014; Lee et al., 2020; Nelson et al., 2022). For instance, Lee et al. (2020) has reported that, despite various interventions and implementation of evidence-based practices, SWD demonstrated 15-26% proficiency in math. Additionally, Bone et al. (2021) found that SWD scored an average of 40 points below their peers without disabilities on the National Assessment of Educational Progress (NAEP). The present research provided empirical support for Vygotsky's theory (1962) and previous research studies that highlighted the academic challenges faced by students with disabilities who study mathematics.

Null Hypothesis Two: EOCT Scores and Online Setting

$H_0$2: There is no statistically significant difference among the Algebra I skills in high school students taking 0, 1, or 2 semesters online, based on their educational setting, as measured by the Georgia Milestones End-of-Course test scores.

Based on a two-way ANOVA data analysis, the Brown-Forsythe and the Welch robust tests, as well as a post hoc Tukey test, the researcher rejected the second null hypothesis. According to the data analysis, there was a significant difference in the EOCT scores in Algebra I among high school students based on the number of online semesters. Specifically, students without disabilities, who took 0 semesters online (N=436, M=480.05, SD=41.183), demonstrated higher EOCT scores than students who took either 1 semester online (N=36, M=453.50, SD=35.178) or 2 semesters online (N=9, M=435.56, SD=21.090). Similarly, students with disabilities who took 0 semesters online (N=79, M=435.15, SD=25.077) demonstrated higher EOCT scores than those who took either 1 semester online (N=13, M=418.38, SD=31.474) or 2 semesters online (N=15, M=428.40. SD=39.554). Additionally, the post hoc confirmed that both 1 and 2 online semesters had a negative impact on the EOCT scores of all participants. However, the difference between the groups of 1 and 2 online semesters was not statistically significant.

The present findings provided support for Vygotsky's sociocultural theory (1962), which stated that for successful learning, students need the MKO who will scaffold the academic content for them. These results also supported the authors who emphasized the role of in-person learning for all students, including SWD (Baier et al., 2018; Halloran et al., 2021; Kulikowski et al., 2022; Lucky et al., 2019; Sass & Goldring, 2021). On the other hand, the present study challenges the findings of multiple researchers who have reported that online learning is beneficial to various groups of learners (Alaniz et al., 2017; Cinquin et al., 2019; Dendir, 2018; Erbil, 2020; Eun, 2019; Kent et al., 2018; Mullen, 2020; Sublett & Chang, 2019). This contradiction makes the existing gap in professional literature even more obvious. The suggestions for future research are discussed in the related section.

Null Hypothesis Three: EOCT Scores and Two Factors

$H_0$3: There is no statistically significant interaction between the high school students' status of disability and their educational setting (taking 0, 1, or 2 semesters online), as measured by the Georgia Milestones End-of-Course test scores in Algebra I.

After conducting a two-way ANOVA data analysis (supported by the HC0 robust test), the researcher failed to reject the third null hypothesis, which stated that there is no significant difference between the GA Milestones EOCT scores in Algebra I in high school students based on their status of disability and educational setting, taking 0, 1, or 2 semesters online. The ANOVA results indicated the lack of an interaction effect between students' disability status and the number of semesters taken online. This result did not necessarily follow from the sociocultural theory since, according to it, students with disabilities lack self-control and self-regulation, which are needed for online learning (Lemons et al., 2018; Ratner & Efimova, 2016). Additionally, many researchers have reported that SWD benefit from in-person learning in math classes, where learners' interactions with others' talk and actions, as well as their interactions with symbols and tools within the classroom environment, facilitates their cognitive development (Ng, 2021; Roth, 2017; Vygotsky, 2017; Walshaw, 2017). Walshaw (2017) maintained that Vygotsky conceptualized mathematical development as a process that involves participation, communication, inclusivity, interactivity, and collaboration.

In special education, researchers investigated the effectiveness of educational technologies and their applications in different educational settings, including face-to-face instructions, blended learning, and online settings. However, there is still no consensus in the findings. While some researchers reported that SWD may benefit from an online setting (Cinquin et al., 2019; Dendir, 2019; Kent et al, 2018; Kotera et al., 2019; Schrader, 2018; Shwan et al.,

2018; Sublett & Chang, 2019), another group of researchers demonstrated that face-to-face instruction allows SWD to increase their academic performance at a higher rate (Eun, 2019; Hedges, 20121; Roth, 2017; Vygotsky, 1978). The proponents of blended learning suggested that this method of delivery is the most effective and efficient for all students, including SWD (Erbil, 2020; Kulikowski et al., 2022; Lu et al., 2018; Mullen, 2020; Thai et al., 2019; Topping et al., 2022). These discrepancies in professional literature suggest the need for further investigations.

Implications

This study aimed to contribute to the existing knowledge about the effectiveness of different educational settings for students with and without disabilities. The researcher identified the main gap in professional literature as the lack of a theory that explains the academic performance of diverse groups of learners in different academic settings. The present research findings yield three main conclusions, each carrying practical implications for education stakeholders.

The first part of the study supported the authors who reported that SWD demonstrated lower academic performance in math classes compared to general education students (Bone et al., 2021; Hughes et al., 2014; Lee et al., 2020; Nelson et al., 2022). Even with various instructional and testing accommodations provided to SWD, this difference could not be eliminated. These findings demonstrated the need for greater support for SWD, particularly in math classes. Education stakeholders and researchers should actively identify effective, evidence-based interventions and strategies that can enhance students' learning experience and improve their outcomes.

The second part of the study supported the researchers who found that *forced e-learning* had a negative impact on the learning outcomes of learners with and without disability (Baier et

al., 2018; Halloran et al., 2021; Kulikowski et al., 2022; Lucky et al., 2019; Sass & Goldring, 2021). The results of the present study demonstrated that students with 1 or 2 online semesters received lower EOCT scores in Algebra I compared to students who had both semesters in the face-to-face setting. This finding highlighted the value of uninterrupted in-person learning experience. Education stakeholders should consider the importance of providing meaningful and engaging instructions in face-to-face settings. This approach is particularly important in math classes, where interactions with others and classroom environment play crucial roles in cognitive development.

The third part of the study failed to find an interaction between the factors of disability status and the number of online semesters that affected the EOCT scores in Algebra I, which contradicted the sociocultural theory and previously reported research findings (Ng, 2021; Roth, 2017; Vygotsky, 2017; Walshaw, 2017). This result indicated that the relationship between disability status and academic performance may be more complex than previously reported. Education stakeholders and researchers should further investigate these factors and explore alternative approaches to support SWD who pursue their education in an online setting.

Overall, these results inform education stakeholders about the effectiveness of different academic settings for diverse learners, emphasizing the need for targeted support and evidence-based interventions. Additionally, the study supported the importance of in-person learning, especially in mathematics. Finally, the complexity of the relationships between disability status and academic performance in different settings called for additional investigation. By considering these findings, stakeholders can work towards improving educational experience and learning outcomes of students with special needs. The limitations of the study are discussed in the next section.

Limitations

The present study has several limitations that pose threats to both internal and external validity. First, the limitations include the population of high school students from two Title I rural public schools in North Georgia, USA. The study results cannot be generalized for any other population. Second, the unique circumstances surrounding the study, such as the COVID-19 lockdowns with *forced e-learning* for many students, cannot be replicated. Third, quasi-experimental studies, like the present study, have inherent threats to internal validity due to the absence of a pretest (Warner, 2013). Also, the lack of randomization in the sample selection negatively affects the validity of the present study. To mitigate these limitations, the researcher used a large sample size. Additionally, treatment fidelity was impacted by inability to assure that both settings had identical instructional materials and assessments. Finally, the uneven distribution of participants among groups (i.e., unbalanced data) resulted in the failed normality and homogeneity assumptions. To address these limitations, the researcher conducted three different robust tests of equality of means.

Recommendations for Future Research

To further expand the knowledge in the field of study, future researchers may consider exploring several directions for their studies. These directions can involve different populations, testing instrumentation, and theoretical constructs, as well as addressing the limitations of the present study. The following questions should be investigated to further enhance our understanding of effective educational practices for diverse learners.

1. What are the major factors that influence the learning outcomes and emotional well-being of students with and without disabilities in different academic settings?

2. To what extent does the improvement of reading skills influence the academic performance of K-12 students with disabilities in mathematics?
3. Which ICT tools and strategies are currently considered the most effective in math education for K-12 students with and without disabilities?
4. Is there a significant difference in the academic performance of students with disabilities based on the scaffolding skills of their MKOs?
5. Is there is a significant difference in the impact of peers as MKOs on the academic achievement and social-emotional development of students with disabilities compared to their peers without disabilities?
6. Is there is a significant difference in the academic performance of high school students with and without disabilities who utilize Artificial Intelligence (AI) as their MKO, compared to those who receive support from a human MKO?
7. Is there is a significant difference in the individual academic performance of K-12 students with and without disabilities based on the group ZPD of their class?
8. What are some methods for measuring a group's ZPD in different subjects?
9. What theoretical frameworks are currently used to explain the phenomena related to the cognitive development of students with disabilities in K-12 inclusive classrooms across different countries?

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APPENDICES

Appendix A: IRB Approval

May 1, 2023

Marina Clayton
Tyler Wallace

Re: IRB Application - IRB-FY22-23-1285 The Causal-Comparative Performance of High School Students With and Without Disabilities in the Face-to-Face and Online Educational Settings

Dear Marina Clayton and Tyler Wallace,

The Liberty University Institutional Review Board (IRB) has reviewed your application in accordance with the Office for Human Research Protections (OHRP) and Food and Drug Administration (FDA) regulations and finds that your study does not meet the definition of human subjects research. This means you may begin your project with the data safeguarding methods mentioned in your IRB application.

Decision: No Human Subjects Research

Explanation: Your study is not considered human subjects research because it will not involve the collection of ***identifiable, private information*** from or about living individuals (45 CFR 46.102).

Please note that this decision only applies to your current application. Any modifications to your protocol must be reported to the Liberty University IRB for verification of continued non-human subjects research status. You may report these changes by completing a modification submission through your Cayuse IRB account.

If you have any questions about this determination or need assistance in determining whether possible modifications to your protocol would change your application's status, please email us at irb@liberty.edu.

Sincerely,

[redacted]
Research Ethics Office

Appendix B: School District Approval

[redacted] SCHOOLDISTRICT

May 5, 2023

Ms. Marina Clayton
[redacted]

Dear Ms. Clayton:

Thank you for submitting your application to conduct research on *The Casual-Comparative Performance of High School Students with and Without Disabilities in the Face-to-Face and Online Educational Settings*. Your proposal to conduct a quantitative study within [redacted] School District has been approved. Please submit a copy of all results or findings to the district.

Sincerely,

[redacted]

[redacted] Superintendent

[redacted]