Shawnee State University
Digital Commons @ Shawnee State University

Master of Science in Mathematics | College of Arts & Sciences

Summer 2022

A STUDY OF THE IMPACT OF THE COVID-19 PANDEMIC ON INTEGRATED MATHEMATICS II OHIO STATE TEST SCORES

Jessica L. Banas

Follow this and additional works at: https://digitalcommons.shawnee.edu/math_etd

 Part of the Mathematics Commons

SHAWNEE STATE UNIVERSITY

A STUDY OF THE IMPACT OF THE COVID-19 PANDEMIC ON INTEGRATED MATHEMATICS II OHIO STATE TEST SCORES

A Thesis

By

Jessica L. Banas

Department of Mathematical Sciences

Submitted in partial fulfillment of the requirements

for the degree of

Master of Science, Mathematics

July 20th, 2022

Accepted by the Graduate Department

7/27/2022

Graduate Director, Date

The thesis entitled '**A STUDY OF THE IMPACT OF THE COVID-19 PANDEMIC ON INTEGRATED MATHEMATICS II OHIO STATE TEST SCORES**' presented by **Jessica L. Banas**, a candidate for the degree of **Master of Science in Mathematics,** has been approved and is worthy of acceptance.

7/27/2022
Date

Graduate Director

July 20th, 2022
Date

Jessica Banas
Student

Abstract

The COVID-19 pandemic took hold of our world and affected nearly every aspect of our lives. It was especially impactful to adolescents, who were already experiencing major stressors and changes in their lives without the added effects of the pandemic. Instead of worrying about who they are going to go to prom with or sitting with at lunch, students may have struggled to help with childcare, how their learning will be delivered to them the following week, or the effects of little to no social interactions. Consistent stressors can lead adolescents to develop dysfunctional neurobehaviour or simply fall into the cycle of stress. Students become stressed, sleep abysmally, become fatigued, which ultimately leads to impaired learning. To complete the cycle, this impaired learning then leads to more stress for the student. (Romeo, 2013, Heller and Adam, 2019). Studies are beginning to come out detailing the levels of stress experienced by adolescence and young adults during the COVID-19 pandemic. It has been found that nearly 50% of students surveyed were experiencing a higher perceived level of stress, with 60% screening positive for anxiety or depression (Aiyer, Surani, Gill, Ratnani, and Sunesara, 2020). This study focuses on students from Rootstown High School in Portage County, Ohio. Data from these students 8th Grade Mathematics and Integrated Mathematics II Ohio State Tests (OST), along with Free and Reduced Lunch Forms and students' learning environments were utilized to conduct this study. Firstly, this study seeks to determine if a student's learning environment was predictive of their Integrated Mathematics II OST scores. This was accomplished with the use of a multiple regression model which controlled for both students socioeconomic status (SES) and 8th Grade Mathematics OST scores. Secondly, this study seeks to determine if there is a statistical significant relationship between SES and Integrated Mathematics II OST scores, learning environment and Integrated Mathematics II OST scores, and lastly to determine which,

SES or learning environment, has a larger significant relationship to Integrated Mathematics II OST scores. These three questions were answered utilizing ANCOVA models. It was determined that there is a significant relationship between SES and Integrated Mathematics II OST scores, as well as, between learning environment and Integrated Mathematics II OST scores. While both were statistically significant relationships, this study found that the learning environment had a larger significant effect on Integrated Mathematics II OST scores. This study also brought light to the widening gap between non-economically disadvantaged and economically disadvantaged students at Rootstown Local Schools following the pandemic, while also illustrating the growth that a classroom teacher can experience from year one to year three of their career. Ultimately, Rootstown High School students' Integrated Mathematics II scores were affected by the learning model they chose for the 2020-2021 school year and economically disadvantaged students performed much worse than their more affluent peers.

Acknowledgements

During my time studying through Shawnee State University I have been fortunate to have the support of many individuals. Firstly, I would like to thank my partner, Timothy, who was there for every celebration and every tear. I admire him greatly and am forever grateful for his encouragement and patience. Secondly, a thank you to my friends, family, and coworkers for the endless hours of support they gave to me on this journey. To the friends who helped me process my hardships and difficult mathematical concepts, I don't know what I would have done without you. Lastly, I would like to thank Dr. Darbro for his support and guidance through this process.

Table of Contents

List of Tables

Table Page

List of Figures

Figure Page

Chapter One: Introduction

Topic of Study

Over the last two years, the COVID-19 pandemic has significantly affected the lives of everyone. It has especially been impactful on the lives of adolescents, who are already experiencing major stressors and changes without the added effects of a worldwide pandemic (Bethune, 2014). Instead of worrying about who they are going to go to prom with or sitting with at lunch, students may have struggled to help with childcare, how their learning will be delivered to them the following week, or the effects of little to no social interactions. Consistent stressors can lead adolescents to develop neurobehavioral disorders or simply fall into the cycle of stress (Thomas, 2021).

Students become stressed, sleep abysmally, become fatigued, which ultimately leads to impaired learning. To complete the cycle, this impaired learning then leads to more stress for the student (Romeo, 2013, Heller and Adam, 2019). Studies are beginning to detail the levels of stress experienced by adolescence and young adults during the COVID-19 pandemic. It has been found that nearly 50% of students surveyed were experiencing a higher perceived level of stress than prior to the pandemic (Aiyer, Surani, Gill, Ratnani, and Sunesara, 2020). This study will determine the effects of COVID-19 on the learning outcomes for students who are required to take the Integrated Mathematics II Ohio state test.

Background of the Problem

The childhood stress continuum extends from healthy, productive stress on one end of the spectrum to toxic stress on the other end. Heightened levels of perceived stress can have negative implications on brain development and brian function (Thomas, 2021). At the height of the pandemic, students' lives changed dramatically and the way in which their education was

presented shifted constantly to accommodate the growing or lessening numbers of COVID-19 cases. Students' daily routines and social lives were changing abruptly on a near weekly basis, which could have led them to experience a greater amount of unhealthy stress. While the pandemic has created more stress, it also put most extracurricular activities on hold. Students who would normally destress through sports or participation in a club no longer had that outlet. This study will look at how this constant change in learning model and greater amount of stress, brought on by the COVID-19 pandemic, may have affected students' Integrated Mathematics II Ohio state test (OST) scores.

While Ohio's State Tests were postponed for the first school year affected by the pandemic, students were expected to perform at pre pandemic levels the following academic year. As stated above, nearly 50% of students are reporting an increase in perceived stress (Aiyer, Surani, Gill, Ratnani, and Sunesara, 2020). These higher levels of perceived stress could then lead adolescents to have their brain development or functions altered, and they could also experience decreased academic or behavioral outcomes, compared to less stressed peers (Thomas, 2021). Of this 50%, 37% suffer from anxiety and 31% from depression (Aiyer, Surani, Gill, Ratnani, and Sunesara, 2020). Along with stress, mood disorders, such as anxiety and depression, can have detrimental effects on student learning and development.

In 2013, it was found that 10%-20% of students met the criteria for an anxiety disorder, while during the pandemic the number of students has soared over 30% (Thompson, Robertson, Curtis, & Frick, 2013, Aiyer, Surani, Gill, Ratnani, and Sunesara, 2020). Students with anxiety suffer from constant fears and worries, which can negatively impact their executive functions and lead them into the cycle of stress. Similarly, depression can lead students to experience disinterest in hobbies, insomnia, inability to concentrate, fatigue, and isolation from family and

friends (Moreh and O'Lawrence, 2016). All of which can affect student achievement and push students into the cycle of stress.

Students do not need to be diagnosed with a mood disorder to have had their academic achievement affected by the pandemic. Isolation from classmates, cancellation of extracurricular activities and persistently changing learning models can lead students to experience negative thoughts and feelings about their education and life in general. Research suggests that adolescents' moods contribute to their learning in the classroom. It has been shown that a negative mood can impair the working memory, the ability to process information and, therefore, a student's overall cognitive accomplishments. Additionally, individuals who are sad may avoid tasks they perceive as academically difficult in fear that those tasks will further ruin their mood (Liew and Tan, 2016).

Statement of the Problem

Despite students heightened perceived levels of stress and the existing research on how this can affect student achievement, students are being expected to catch up and achieve as they did prior to the pandemic with little support in acclimating to the world that COVID-19 has created (Mann, Smith, Kristjansson, Daily, McDowell, and Traywick, 2021). It is unknown how the COVID-19 pandemic has affected students academically, therefore there is a need for this study to shed light on this topic.

Purpose of the Study

The motivation for this study stems from the lack of research on the overall effects of the COVID-19 pandemic on students' educational progress and achievement. In order to research how the COVID-19 pandemic has affected student achievement, this study will look at data from Integrated Math II students at Rootstown Local Schools. The thesis will have a quantitative

research design, with Integrated Math II OST scores for the 2018-2019 and 2020-2021 school years being the dependent variable. The independent variable will be the instructional units, defined as the method in which education was delivered to students.

There are three categories of instructional units; Pre-Pandemic Traditional, During Pandemic In School, and During Pandemic Virtual. This study will also control for students 8th grade mathematics OST data from the 2016-2017 and 2018-2019 school years and students' socioeconomic status for the 2018-2019 and 2020-2021 school years. All data mentioned was collected by Rootstown Local Schools during the respective school years and cleansed by a school administrator prior to access by the research team.

Pre-pandemic and post-pandemic Integrated Mathematics II OST scores will be compared in an attempt to predict Integrated Mathematics II OST scores, while controlling for 8th grade mathematics OST scores and students' socioeconomic status, from the instructional unit. The three instructional units that will be considered are pre-pandemic, during pandemic in school, during pandemic virtual. This study is important to the field of education, for students have been expected to continue on with their education while experiencing more stressors than ever before. The impact of these stressors must be documented and analyzed as the pandemic is far from over. The significance of this study is to determine the effect of the pandemic and varying instructional units on students' Integrated Mathematics II OST scores.

Significance of the Study

With the lack of research around this topic, this study will provide state and national policy makers with research on how states of emergency, specifically lockdowns, affect students academically. Additionally, it could assist policy makers in determining the necessity for statewide testing during states of emergency or natural disasters. By examining the relationship

between students' learning models and their Integrated Math II OST scores, high school administrators, policy makers, and university administrators can see the effect the pandemic has had on student academic achievement.

Primary Research Questions

This study works to address the following research questions:

Question 1: Is changing the instructional unit, during the COVID-19 pandemic, when controlling for 8th grade mathematics Ohio state test scores and socioeconomic status, a significant predictor of Integrated Mathematics II Ohio state Test scores?

Question 2: Is there a significant difference between instructional units and Integrated Mathematics II Ohio state test scores, when controlling for 8th grade mathematics Ohio state test scores and socioeconomic status?

Question 3: Is there a significant difference between socioeconomic status and Integrated Mathematics II Ohio state test scores, when controlling for 8th grade mathematics Ohio state test scores and instructional units?

Question 4: Which has a larger significant effect on Integrated Mathematics II Ohio state test scores, type of instructional unit or socioeconomic status, when controlling for 8th grade mathematics Ohio state test scores?

Hypotheses

The hypotheses for this study are as follows:

Hypothesis 1: Changing the instructional unit, when controlling for 8th grade mathematics Ohio state test scores and socioeconomic status, will be a significant predictor of Integrated Mathematics II Ohio state test scores.

Hypothesis 2: There is a significant difference between instructional units and Integrated

Mathematics II Ohio state test scores, when controlling for 8th grade mathematics Ohio state test scores and socioeconomic status.

Hypothesis 3: There is a significant difference between socioeconomic status and Integrated Mathematics II Ohio state test scores, when controlling for 8th grade mathematics Ohio state test scores and instructional units.

Hypothesis 4: Type of instructional unit has a larger significant effect on Integrated Mathematics II Ohio state test scores than socioeconomic status, when controlling for 8th grade mathematics Ohio state test scores.

Research Design

The participants of this study are students from Rootstown Local Schools, a rural school district in Northeastern Ohio. The research team will be utilizing 8th grade mathematics OST data from the 2016-2017 and 2018-2019 school years, integrated Mathematics II OST data from the 2018-2019 and 2020-2021 school years, and free lunch data from the 2018-2019 and 2020-2021 school years. All data that will be used in the study has been collected by Rootstown Local Schools and was cleansed of student identifiers by a school administrator prior to access by the research team.

This study will be both predictive and hypothesis testing. The analysis of Integrated Mathematics II OST scores will be utilized from before and during the pandemic to discover if Integrated Mathematics II OST scores can be predicted from the instructional unit when controlling for 8th grade mathematics OST scores and socioeconomic status. This analysis of the factors that predict Integrated Mathematics II OST scores will be utilized to determine which factor has the largest effect and test hypotheses. Test will also be ran to determine if a significant relationship exists between socioeconomic status and Integrated Mathematics II OST scores

while controlling for 8th grade OST scores and instructional unit, and if a significant relationship exists between instructional unit and Integrated Math II OST scores while controlling for 8th grade OST scores and socioeconomic status.

Theoretical Framework

Standardized testing, such as the Integrated Math II OST, reaches as far back in our history as 1845 when Horace Mann, who is often referred to as the Father of Common School (Levin, 1992), suggested students in Boston Public School take written exams to demonstrate their knowledge (Gershon, 2015). Before Mann's idea of tests to measure achievement took off, there was a rise in popularity of assessments to test students' overall ability, such as an intelligence test. This led to the birth of the College Entrance Examination Board in the 1920s, which we know of today as the Scholastic Aptitude Test, or SAT.

It wasn't until the 1960s that standardized testing began to be pushed by the federal government. From there these standardized tests grew in importance as world events, such as the Cold War, caused schools to be pressured into producing the most productive workforce possible (Gershon, 2015). In this quest to create a competent workforce and identify intelligent students, students of color and those from lower economic statuses were left behind, due to the results of wide bias in standardized testing. According to the National Educators Association, test makers look for obvious bias in test questions, but they do not always screen for the underlying bias that exists in high stakes tests (Rosales & Walker, 2021).

Despite these flaws, the pressure on public schools has only become greater as the years have passed, to the point that a world-wide pandemic only caused the federal government to pause standardized testing for a school year. Now more than ever, a great amount of pressure is put on students and schools by federal and state governments to produce quality test scores,

while our world is fighting to find a new normal. Students are under more stress than ever and still expected to participate in high-stakes testing. Due to this fact, policymakers and education proponents are now looking at ways to possibly utilize this data to judge schools differently (Field, 2021).

In the past many states utilized test data to grade schools on an A-F scale, however, now some policymakers are looking at different ways to use data from state mandated tests. This is due to the fact that many students' learning has been disrupted over the course of the COVID-19 pandemic. Additionally, with the mixture of online and in person students, state testing data is not as complete as it was seen to be prior to the COVID-19 pandemic, for not all remote students are making it into schools to test. This causes difficulties when attempting to utilize this data to analyze educational trends and shortcomings. Therefore, state mandated tests can be helpful in determining knowledge gaps between populations and schools, but there will be gaps in student data that will need to be taken into consideration (Field, 2021).

To hold all students and schools to the same standards of achievement on state mandated tests as before the COVID-19 pandemic is unreasonable, due to disruptions in student education and the difficulties present in testing all students. There is hope that the national government will rework the entire process of state mandated testing, but this is highly unlikely at this time (Field, 2021). As data and research of the effects of the pandemic continue to be published, policy and lawmakers will have a clearer picture of how the COVID-19 pandemic has affected students' test scores, and the role of state mandated testing will hopefully be reevaluated.

Assumptions, Limitations, and Scope

This research assumes that students tried their best on the Integrated Math II OST and 8th grade math OST, that the data presented to the research team by Rootstown Local Schools is

accurate and that parents of students were truthful when filling out Free Lunch forms, which were utilized to determine students socioeconomic status. In reality, the quality of the data presented to the research team is unknown, and Rootstown is a relatively small, rural school, so the data set is smaller. Ultimately, the data and analysis applies only to Rootstown Local Schools, and may not apply to other schools within Ohio. This cannot apply to schools outside of Ohio, for the research is based around Ohio state test scores. Only Integrated Math II OST data is considered, so this research pertains specifically to student achievement in Integrated Math II.

Definition of Terms

To avoid confusion, here are definitions to consider:

Integrated Mathematics II Ohio State Test: The end of course exam presented to high school students to determine their level of learning and retention of Ohio's standards for Integrated Mathematics II. These standards include modeling, number and quantity, algebra, functions, geometry, and statistics and probability (Ohio Department of Education, 2018)

8th Grade Mathematics Ohio State Test: The end of course exam presented to 8th grade students to determine their level of learning and retention of Ohio's standards for 8th grade mathematics. These standards include the number system, expressions and equations, functions, geometry, statistics and probability (Ohio Department of Education, 2017).

Free Lunch Data**:** At the beginning of each school year in Rootstown Local Schools, if students qualify for free lunches their family fills out paperwork to determine this free lunch status. These students are then identified as an economically disadvantaged population.

Instructional Unit: The method in which education is delivered to students.

Pre-Pandemic Traditional Instructional Unit: This instructional unit occurred before the pandemic, where students received a traditional education.

Pandemic-Traditional Instructional Unit: This instructional unit occurred during the pandemic, where students received an education at school. This instructional unit varied throughout the school year depending on the levels of COVID-19 cases in the Rootstown community and the surrounding Portage County. At the height of cases, students were at home learning remotely from their teachers. The majority of the year was spent in a hybrid model, where students learned online half the time and in person the other half. There were also a few weeks of traditional, in person learning.

Pandemic-Virtual Instructional Unit: This instructional unit occurred during the pandemic, where students opted to not attend traditional school and undertook a completely virtual, self paced education through Jefferson County's Virtual Learning Academy.

Summary

Research has shown how stress, depression, anxiety and negative mood can affect learning and processing, despite this, students have been expected to achieve academically during the COVID-19 pandemic to the same level as students prior to the pandemic. The remainder of this thesis will analyze the relationship between Integrated Math II OST scores and the learning model that preceded them, while controlling for 8th grade math OST scores and socioeconomic status. It will also address if socioeconomic status or instructional units had a larger effect on Integrated Math II OST scores and if a significant relationship exists between socioeconomic status or instructional units and students Integrated Math II OST scores.

The goal of this paper is to provide high school administrators, policy makers, and university administration with data on how the COVID-19 pandemic has affected students academically. Next, this thesis will dive into the literature that currently exists around mental health and student achievement, and then will go on to discuss the research methodology and

results. Ultimately, this thesis will be presented in five chapters and address how varying instructional units, during the COVID-19 pandemic, affect Integrated Mathematics II Ohio state test scores and if these test scores can be predicted from instructional units, such as tradition, hybrid and virtual learning, while controlling for 8th grade OST scores and students' socioeconomic status.

Chapter Two: Literature Review

Introduction

According to The World Health Organization (2022), the coronavirus disease (COVID-19) is “an infectious disease” that causes “mild to moderate respiratory illness” in most cases. This disease quickly led to the most compelling public health crisis of modern times (Aiyer, Surani, Gill, Ratnani, and Sunesara, 2020). With this crisis came social distancing measures, stay-at-home orders, and stress. School closings forced adolescents to navigate online learning and feeling of isolation with no prior preparation (Orben, Tomova, & Blakemore, 2020; Garcia & Weiss, 2020). Life changed dramatically for many students, as a plethora of parents and caregivers were either laid off from work or required to work overtime depending on the nature of their jobs. This caused older students to be required to care for younger siblings and keep them engaged with school work or even go to work themselves to help support their families (Whitehurst, 2020).

The instability created by the COVID-19 pandemic put a tremendous burden on students' mental health and academic performance (Aiyer, Surani, Gill, Ratnani, and Sunesara, 2020; Garcia & Weiss, 2020). Research into students’ mental and emotional state during this pandemic has revealed that students are reporting higher levels of perceived stress, suffering from a greater amount of depression and anxiety, and are, overall, feeling negative (Aiyer, Surani, Gill, Ratnani, and Sunesara, 2020; Camacho-Zuniga, Pego, Escamilla, & Hossini, 2021). Chronic stress during adolescence has been shown to alter areas of the brain that deal with memory and learning (Romeo, 2017). Correspondingly, research has demonstrated that higher levels of perceived stress leads to poor memory retrieval, memory storage, and intellectual performance. Mood disorders, such as anxiety and depression, have also been shown to hinder students’ scholarly

abilities (Pascoe, Hetrick, & Parker, 2020). Even without a diagnosed mood disorder, a student's mood alone can play a significant role in their scholastic achievement (Aiyer, Surani, Gill, Ratnani, and Sunesara, 2020).

A Brief History of COVID-19 Pandemic in Relation to Students and Ohio Education

In March of 2019, most schools were preparing for spring break as Governor Mike DeWine placed Ohio under a state of emergency after three people tested positive for the COVID-19 virus. Governor DeWine called for schools to begin their spring breaks early and closed all schools for three weeks. A couple of weeks passed and the number of Ohioans contracting COVID-19 soared and hospitalizations began to be linked to the virus. March 22nd, Governor DeWine, in conjunction with Ohio's Department of Health, issued a stay-at-home order causing school systems to create online learning environments overnight (Clay, 2020). Like numerous other education systems, Ohio's schools were not prepared for a situation such as this and did not have the structure needed to maintain effective teaching and learning throughout a stay at home order. Regardless of the school district, instructional and learning time was reduced due to this lack of preparedness (Garcia & Weiss, 2020).

While there are no past events of this magnitude to use as a direct comparison, research has demonstrated that a loss of instructional time hinders students' academic performance. On average, a student's scholastic achievement rose by about 0.3 standard deviations to 0.7 standard deviations per school year depending on subject and age. During the 2019-2020 school year, on average, learning institutions lost a third of instructional time, which would suggest a loss of at least 0.1 standard deviations of increased scholarly performance. Confirming this assertion is research on student absenteeism, for there exists a negative trend between student learning and school days missed. This trend worsens the more often a student misses school (Garcia & Weiss,

2020). Along with lost instructional time, access to technology also hindered student learning during the 2020 stay-at-home order.

A study conducted in early April of 2020 found that nearly one in five families found it to be ‘very likely’ to ‘somewhat likely’ that their children would not have access to the proper technology to keep up with online school work. This study went on to find that three in ten parents surveyed believed that their child would have to complete assignments with the use of a cell phone.This digital divide is a critical piece in assessing student access to education during the stay-at-home order, and disproportionately affected minority students and students who come from rural and low-income backgrounds (Lake & Makori, 2020). Even if families had the required technology to facilitate effective online learning, these devices may not have been up to date or were shared between multiple students or parents (Garcia & Weiss, 2020). A student who had all required access to technology still had other hurdles to overcome that could have affected their time spent learning.

While already struggling to adapt to an online learning environment, unlikely circumstances, caused by the pandemic and stay-at-home order, forced many students to take on extra duties and roles around their households. This also required many older students to take on the role of caregiver for younger siblings, as daycares closed. Students saw their lives divided between attempting to stay on track with their own online work and assisting their sibling in doing the same, then keeping them entertained when school work was not the focus. Conversely, students whose parents or caregivers had lost their jobs as the stay-at-home order began needed to work frontline jobs to help keep their families afloat financially. In order to not let their teachers, their families, or themselves down, students in these situations had to consistently work hard (Whitehurst, 2020).

Along with adjusting to new roles in their families and online education, students faced a lack of face-to-face communication with friends and their extended families and saw their extracurricular activities put on hold. Adolescence is a stage of life defined by an increased need for social stimulation and interactions. As society attempted to create distance between people, many opportunities for social interaction outside of the digital world became nonexistent. It is also important to mention that social distancing did not affect all students in the same way. Students who came from high functioning families and had positive relationships with their parents or caregivers may not have seen the same struggles as those students who lack those quality family connections (Orben, Tomova, & Blakemore, 2020).

Aside from opportunities for social interactions, other services provided by educational institutions, such as access to a counselor or other mental health services, became harder to access as the stay-at-home order took effect. Vulnerable teens who would normally benefit from these services were put at risk of worsening their current mental health problems or developing new ones. This closure of schools took away the protective services provided to teens to help with their mental health and those that help to identify abuse. Students of abusive households were forced to be isolated with their abusers, due to the stay-at-home order, which could have led to an escalation of abuse or domestic violence. At risk students were extremely susceptible to developing mental health issues or experiencing abuse during this time where community services were difficult to access (Thankur, 2020).

With all the turmoil caused by the COVID-19 pandemic, The U.S. Department of Education decided to waive the end of year state testing for the 2019-2020 school year (Ohio Department of Education, 2020). Students spent the rest of the 2019-2020 school year online and as June 2020 progressed Ohioans started to venture from their homes once again, as lawmakers

put health mandates into effect, such as the requirement to wear masks in public. As the 2020-2021 school year approached, students were required to wear masks, but the hope of extracurricular activities resuming was becoming a reality (Ballotpedia, 2021). Life for students began to return to a version of normal as winter approached. Unfortunately, with winter came an inflation of COVID-19 cases, and schools across Ohio began transitioning back to online learning prior to winter break (Nicks, 2021). Despite varying learning models and other challenges still present to school districts and students from the COVID-19 pandemic, the U.S. Department of Education decided to proceed with State Testing for the 2020-2021 school year (Ohio Department of Education, 2021).

Students' feelings of disconnection from their learning environments was one of the numerous challenges presented to students by the COVID-19 pandemic. Students of all intellectual backgrounds felt the emotional burden of the pandemic, and many saw it affect their mental health (Camacho-Zuniga, Pego, Escamilla, & Hossini, 2021). While an online learning environment can be productive, it also presents issues that many education systems were not ready to combat at such a short notice (Garcia & Weiss, 2020).

Positives and Negatives of Online Learning

With a major decrease in face-to-face social interactions and the move to online schooling, adolescents were documented spending more than double the amount of time in front of a screen during the stay-at-home order than before COVID-19 hit. Excessive screen time can lead to poor sleep and sedentary lifestyles, along with mental and physical health problems (Thankur, 2020). While there are many negatives to implementing an online learning model, it is not without its possible benefits and strengths. Evidence that supports the effectiveness of online

learning is still limited, but, regardless, without the proper training students and teachers struggled to gain success in an online platform (Garcia & Weiss, 2020).

While there is a finite amount of data on online learning, homeschool data can be utilized to shed light on the effectiveness of learning from home. In 2016, homeschool enrollment was a little over 3% of K-12 students in the United States. Research shows that homeschooled students generally perform higher than their non-homeschooled peers. The fact that homeschooling leads to the opportunity for a smaller "teacher" to student ratio, as well as more personalized instruction, could lead to a higher success rate in this population. This information implies that, under the right circumstances, learning from home could be a positive and rewarding experience (Garcia & Weiss, 2020).

For online learning to be successful, it is imperative for teachers and students to receive the proper training and have access to the necessary technology. Research has suggested that at the start of the pandemic, students transitioned to an online learning environment without the necessary training to know how to learn online. The majority of students have utilized technology only for leisure activities and, overnight, were expected to make the shift to work with technology educationally. Remote learning required students to ignore all the distractions that were readily available to them through the same technology they needed to use to access their education. Data from online charter schools has demonstrated the importance of student engagement and caregiver support in the online learning process (Garcia & Weiss, 2020).

Ideally, parents and caregivers were readily available to assist students with their course work and to redirect their attention. However, many parents were required to focus on working from their home office or were occupied providing childcare for younger children, as daycares closed and family members were encouraged to social distance (Clemens, Deschamps, & Fegert,

2020). Anecdotally, researchers have identified three patterns of adolescent life, post stay-at-home order. There was a group of students who seemed to prosper from a quiet homelife and supportive parents or caregivers. These students engaged with friends and classmates online and enjoyed their online learning experience. A second group saw their developmental opportunities delayed due to a lack of resources or parental support. A third group of students, who came from negative households, found themselves deprived of the safety and security provided by schools. Many of the students in this category suffered from the lack of services that schools and governments provide to the community (Clemens, Deschamps, & Fegert, 2020). Regardless of a student's situation, transitioning to online learning required students to have higher than normal selfcontrol to stay caught up on school work and classes without the direct supervision of a teacher (Garcia & Weiss, 2020).

Even if a student was successful in their online education, they were still missing out on other crucial aspects of in-person education, such as the development of social and emotional skills. The improvement of these skills occurs through the growth of personal relationships and positive interactions with peers, teachers, and coaches. Extra curricular activities also play a vital role in social emotional development (Garcia & Weiss, 2020). These opportunities for skill improvement were replaced by online interactions. Research has shown that while the internet has led to endless possibilities for communicating with people around the globe, this online communication is less emotionally rewarding than face-to-face interactions. Between delayed responses, the possibility for passive engagement, and the lack of nonverbal cues, online interactions do not hold the same value as in-person ones (Plumridge, 2020).

Along with inauthentic social interactions, an increased amount of screen time can lead to other problems for adolescents. Prior to the pandemic, it was estimated that the average

adolescent participated in 3.8 hours of screen time per day. A survey conducted at the beginning of the COVID-19 pandemic found that the mean daily screen time for adolescents was 7.7 hours per day (Nagata, Cortez, & Cattle, 2022). A boost in screen time such as this could lead adolescents to be at risk of obesity, sleep problems, neck and back pain, and mental health issues. The more time a student spends in front of a screen the less time they are utilizing to be active, which could lead to a surge in sedentary activities, including streaming and gaming. Too many sedentary activities can lead to weight gain, a decrease in heart health, and an increased risk of diabetes (Mosley, 2020).

Sleep problems can also develop from an extension of screen time, for the light from the screen can affect the brain melatonin production and cycle of sleep. The disruption of this cycle can prevent adolescents from getting quality rest, which can lead to a rise in mental health issues and substance abuse. While the light from the devices can lead to sleep loss, social media can also impact adolescents' quality of sleep. Many adolescents sleep with their phone next to them or even under their pillow, which leads to the possibility of each vibration or ring waking them throughout the night. This need to be connected at all hours is driven by adolescents' fear of missing out on opportunities to build their social media presence (Health Matters, 2021).

Research also demonstrates that too much screen time can negatively affect adolescents' mental health (Mosley, 2020). A greater amount of screen time can lead adolescents to an upsurge in the amount of time they spend on social media. Research argues that increased time on social media can lead to a greater risk of experiencing mental health issues. For students who are already experiencing symptoms of depression or anxiety, a larger presence on social media could increase their feelings of anxiety, depression, and alienation. Social media has facilitated a culture of comparison and adolescents who are concerned with their self image will be in danger

of comparing themselves to those on social media. These adolescents are then liable of feeling inadequate to the online personas surrounding them, which, again, can lead to mental health issues or suicide. This hazard becomes even greater when cyberbullying is taking place, and the more time a teen spends online the greater the likelihood of becoming a victim of cyberbullying becomes (Health Matters, 2021).

While in the right home environment, online learning can help a student to flourish, those situations are few and far between. The COVID-19 pandemic has led to an increase in many students' responsibilities and the self control required to be successful learners. Even students who saw academic success during the stay-at-home order missed out on the social emotional skill development that in-person school and extracurriculars offer (Garcia & Weiss, 2020). This lack of face-to-face social interaction caused many adolescents to double the amount of time they spend in front of a screen, compared to before the pandemic (Nagata, Cortez, & Cattle, 2022). While these online social interactions can be positive, they cannot replace traditional in-person communication and can lead students to negative mental and physical health issues (Mosley, 2020). While the COVID-19 pandemic is unique, students have been put through similar social isolation due to natural disasters in the past.

Effects of Isolation on Adolescents

Humans are a social species, so during a time of social distancing, such as the COVID-19 pandemic, it is not surprising that adolescents would feel a sentiment of isolation (Heller, 2019). A similar sense of desolation was felt by students in New Orleans during the natural disasters of hurricane Katrina and Rita in 2005. Following these disasters, displaced students experienced a drop in scholastic performance equivalent to 0.07 to 0.22 standard deviations compared to their nondisplaced peers. Principals reported that displaced students were more likely than their

nondisplaced peers to engage in negative behaviors and less likely to engage in positive behaviors like after school activities (Garcia & Weiss, 2020).

This desire to engage in negative behaviors could be connected to the students' sense of isolation from their peers during their time of displacement. Distancing from peers during natural disasters, such as hurricane Katrina or the COVID-19 pandemic, could cause adolescents to feel that they have been separated from the activities and social integrations that made their lives feel purposeful. When an individual loses their feelings of purpose and belonging in the context of society, they are prone to negative cognitive effects such has feelings of isolation, anxiety, depression, poor quality of sleep, or suicide. These effects have been recorded to be especially prevalent after disasters (Zhang, Yan, Zhao, & Yaun, 2015).

These negative emotions were documented by adolescents during the COVID-19 pandemic. While social distancing and school closures may have slowed the spread of the virus, they threaten to worsen existing mental health issues and put adolescents at risk of developing mental health issues in the future. Adolescents were living with a constant fear of the virus and the state of the world. These worries could lead to stress-related disorders, depression, anxiety, and substance abuse. With the closure of school and community centers, resources that were once in place to help adolescents with mental health issues were not readily available or as easily accessible, which led to a further mental health crisis (Thakur, 2020).

Another cause of these worries and mental health issues arose from the disruption to daily routines and schedules (Lee, 2020). This can be especially true for students who experienced mental health issues prior to the COVID-19 pandemic. While mental health resources provided by schools are important, schools also offer students a consistent routine and reason to participate socially. School closures gave students little to no reason to leave their rooms, which caused

many to distance themselves from their families and refuse to participate in basic self care activities, such as showering or eating (Lee, 2020). Presenting less of a reason to leave their rooms, adolescents were also missing out on fun activities, including sports and clubs, that occurred consistently outside of the home. These are generally positive interactions with coaches, teachers, and peers that students no longer had to look forward to. (Clemens, Deschamps, & Fegert, 2020).

These missed opportunities are so vital, for adolescence is a period of development represented by an increased desire for social interaction, so it follows that students would have encountered more feelings of stress, depression, isolation, and instability (Orben, Tomova, & Blackmore (2020). Instability is defined as “the experience of abrupt, involuntary, and/or negative change in individual or family circumstances"(Sanderstrom & Huerta, 2013). States of emergency, like that caused by hurricane Katrina or the COVID-19 pandemic, can lead students and their families to endure instability. Due to the stay-at-home order of the COVID-19 pandemic, some parents were laid off from work or quit their jobs to provide child care. Research has shown that family income is strongly related to student intellectual success and cognitive abilities. Poor social-emotional development can also be a result of parental job loss (Sanderstrom & Huerta, 2013). Therefore, students who are already struggling to keep up with school and develop socially and emotionally may have been set even further behind due to their parents' employment circumstances. On the other end of the spectrum, some adolescents may not have received the support they required at home, due to parents working overtime during the pandemic. Disasters can cause society to go through economic shock, which causes parents to work longer hours. This gave parents and caregivers less time at home helping their children with school work and social-emotional challenges (Garcia & Weiss, 2020).

States of emergency can lead to an upheaval of students' routines and positive interactions, which, as seen with the natural disaster caused by hurricane Katrina, can lead to learning loss and engagement with negative behaviors for students who were affected (Garcia & Weiss, 2020). As data collection is beginning on students' mental health during the COVID-19 pandemic, it can be seen that these trends may apply to this disaster, as well. Research has shown that during the pandemic nearly 50% of students described higher perceived stress than before the stay-at-home order, 37% suffered from anxiety and 31% from depression (Aiyer, Surani, Gill, Ratnani, and Sunesara, 2020). This is very concerning considering that, in 2013, it was found that 10%-20% of students met the criteria for anxiety disorder alone and it is now affecting over 30% of adolescents (Thompson, Robertson, Curtis, & Frick, 2013, Aiyer, Surani, Gill, Ratnani, and Sunesara, 2020).

Adolescent Stress

The American Psychological Association found, in 2017, that stress and depression among adolescents has risen significantly over the previous eight years, which was still two years prior to the COVID-19 pandemic (Heller, 2019). During the pandemic, students reported even higher levels of perceived stress (Aiyer, Surani, Gill, Ratnani, and Sunesara, 2020). While academics are the greatest source of stress for adolescents, social stress is a close second that carries much more emotional impact (Heller, 2019). The social distancing of the pandemic has caused social media to be a prime source of social interaction for adolescents, which is already known to have adverse effects on adolescent mental health (Health Matters, 2021). In addition to stress from online interactions, adolescents in the COVID-19 pandemic had no outlet for their negative emotions and stress. With the closure of schools, extra curricular activities were also

halted, and activities that students once used to destress and unwind became nonexistent (Garcia & Weiss, 2020).

Childhood stress can be described as a continuum ranging from healthy, normal, productive stress on one end of the spectrum to traumatic stress on the other. Traumatic stress, such as that brought on by the pandemic, is categorized by feelings of instability and hopelessness (Thomas, 2021). These are feelings that adolescents in the pandemic were describing (Camacho-Zuniga, Pego, Escamilla, and Hosseini, 2021). An increase in stress can push adolescents into the cycle of stress. When an individual experiences high levels of stress throughout the day, stress hormone levels remain high into the evening and can be detrimental to quality rest. This then leads to fatigue, grogginess, and lack of focus, which for a student can mean academic struggles, which then leads to more stress (Heller, 2019). Along with creating sleep issues, traumatic stress can have adverse side effects on a child or adolescents developing brain, which can potentially lead to problems later on in life (Thomas, 2021),

Stress and the Brain

Research has shown that prolonged periods of stress or exposure to stress hormones can lead to negative impacts on the developing adolescent brain. While there is not a plethora of research on how the human adolescent brain reacts to stress, there has been extensive research into how it affects the brains of adolescent rats. Research is conducted on rats that are approximately 30-60 days old, which approximately translates to adolescence in humans, about age 10-18 (Romeo, 2017). Not all stress research has been performed with human subjects, however rats are very similar to humans genetically, biologically, and behaviorally (Ball, 2016). Research on rats has shown that portions of the developing brain, including the amygdala,

hippocampus, and prefrontal cortex are susceptible to structural alterations due to chronic stress or stress hormones (Romeo, 2017).

Mediating fear learning, reward, aggression and sexual behavior are all, in part, controlled by the portion of the brain known as the amygdala. The amygdala is made up of subnuclei, including the medial, central, and basolateral nuclei. Research pertaining to adolescent humans and rats has demonstrated that during adolescents there is a volumetric growth of areas of the amygdala, including the basolateral and medial nuclei. The current research suggests that this change occurs in the beginning stages of the transition to adulthood. When constantly exposed to restraint stress, adolescent rats demonstrate a decrease of dendritic spine density and an overall increase in the dendritic complexity of the neurons of the basolateral nucleus. Another study of rats who were exposed to social isolation stress found that in the basolateral and central nuclei of the amygdala there was a decrease in spinophilin, which is a protein producer of the dendritic spines. Therefore, this suggests that a decrease in spine density would be associated with a decrease in spinophilin, which would mean that consistent exposure to stress during adolescence leads to a decrease in spine density. Rats that have been exposed to constant stressors to the point of amygdala alteration have demonstrated signs of anxiety. Ultimately, this research suggests that exposure to chronic stress in adolescents leads to alterations of the amygdala, which, with greater research, could be connected to anxiety (Romeo, 2016).

Another part of the brain that works with stress is the hippocampus formation, which consists of the hippocampus and the dentate gyrus. Along with stress reactivity, the hippocampus is critical in mediating learning and memory, as well as many aspects of emotional function. Neuroimaging of the hippocampal formation demonstrates that, similar to that of the amygdala, the hippocampus undergoes significant structural changes in early adolescence. This is also

mirrored in adolescent rat studies. In studies of adult rats, the hippocampus formation demonstrates sensitivity to stress-related hormones, such as cortisol, but if given ample time to recover, the effects are reversed. A study of children, ages eight to fourteen, with post-traumatic stress symptoms demonstrated a decreased volume of their hippocampal formations. This was thought to be caused by the relatively high levels of cortisol that are experienced with post-traumatic stress. These findings are duplicated in a study of rats which found that chronic variable physical stress during adolescence increased the expected growth of the hippocampal formations. Thus, the conclusion can be drawn that stress can induce alterations of the hippocampus in adolescence. Since the hippocampus plays such a vital role in learning and memory, this research could explain why adolescents exposed to chronic stress undergo a decrease in learning and memory abilities (Romeo, 2016).

The prefrontal cortex, through neuroimaging and histological studies in postmortem human and non-human brain tissue, demonstrates not only an increase in volume, but also impressive structural changes during adolescence. In young adulthood, this is then followed by a duration of cortical thinning. The regulation of emotional behaviors, fear extinction, and executive functions are all integral components of the prefrontal cortex’s functions. When exposed to restraint stress, adolescent rats’ prefrontal cortical neurons demonstrate dendritic degeneration. Similarly, social isolation stress in early adolescent rat development was seen to reduce the protein makers of synaptic plasticity, such as spinophilin and synaptophysin, in the prefrontal cortex. Once removed from isolation stress, these rats' prefrontal cortex remained altered for over three weeks. It then leads that this alternation of the prefrontal cortex could affect an adolescent's emotional behaviors or executive functions (Romeo, 2016).

Stress and Learning

While heightened levels of perceived stress can have negative implications on brain development, it can also hinder brian functions, such as memory integration and retrieval. (Thomas, 2021; Heller, 2016; Vogel & Schwabe, 2016). Cortisol, a stress hormone, plays a role in learning and memory. A study was conducted on charter schools in New Orleans to determine the effects of student cortisol levels on their state test scores. Students' cortisol levels were measured once during an ordinary school week, a second time right before a standard in school test, and then, lastly, directly prior to students taking the state's high stake exam. Overall, it was detailed that cortisol levels spiked the most prior to the high stakes exam, and those levels were highly predictive of student's scores. Those who scored the lowest produced the lowest and the highest levels of cortisol, while those who scored the best underwent a moderate rise in the stress hormone. The difference in test scores was most significant for math, for the students with high levels of the stress hormone scored 0.4 standard deviations lower than their peers with modest levels of cortisol increase (Heller, 2016). These results were duplicated in another study which found that more than 60% of students in the bottom quarter of academic achievement mentioned feeling anxious about tests regardless of their preparation or knowledge. These two studies suggest that higher stress levels are associated with negative scholastic performance (Pascoe, Hetrick, & Parker, 2020).

Memory functions and stress are often thought to be represented by an inverted U-shaped curve, where memory and stress meet at an ideal range, but if one moves above or below this range memory decreases (Salehi, Cordero, & Sandi, 2010). When moving too far away from that optimal point, stress has the capacity to hinder the brain's memory retrieval abilities (Hobson, 2018). For instance, in a stressful social situation it is highly likely that one will forget the names

of those they have just been introduced to (Bangasser & Shoes, 2010). It has also been found that moderate to high levels of stress before an exam can negatively impact memory retrieval (Vogel & Schwabe, 2016; Willis, 2014). Therefore, it can be concluded that high levels of cortisol in healthy participants translates to poor retrieval of information (Bangasser & Shoes, 2010).

While high perceived stress affects the brain's ability to retrieve information, it also appears to hinder the processing and storing of new information. This ability to store new information is greatly affected by the amount of stress that an adolescent is under. When stress is accompanied by great emotion or exceptional trauma, a vivid memory of the information surrounding a situation can occur, which suggests that memory formation can be boosted if it is directly preceded by severe stress. However, if material is not directly related to the severe stressor it may not be remembered later. Therefore, stress that is pertinent to what is being learned and induced just prior to learning can be helpful to memory encoding, but unrelated or overwhelming stress can have the opposite effect. It has been demonstrated that prolonged exposure to repeated stressors during critical times in brain development can have strong adverse effects on learning and memory (Vogel & Schwabe, 2016; Willis, 2014). Due to the COVID-19 pandemic, high school students have been exposed to high levels of stress, which has led to higher rates of depression and anxiety in this age group (Aiyer, Surani, Gill, Ratnani, and Sunesara, 2020).

Adolescent Mood Disorders and Mood

During the COVID-19 pandemic, students were reporting extreme levels of stress, depression, and anxiety. Of these students nearly 60% screened positive for anxiety or depression. (Aiyer, Surani, Gill, Ratnani, and Sunesara, 2020). Both anxiety and depression are known to negatively affect not only health and well-being, but also intellectual achievement

(Pascoe, Hetrick, & Parker, 2020). A student does not need to be diagnosed with a mood disorder, such as anxiety or depression, to see negative trends in their scholastic achievement. Research suggests that adolescents' moods contribute to their learning in the classroom. A negative mood can impair the working memory and, therefore, a student's cognitive accomplishments (Liew and Tan, 2016). While it is not uncommon for adolescents to have depression, anxiety, or negative moods, the COVID-19 pandemic has led to an increase in recorded cases (Aiyer, Surani, Gill, Ratnani, and Sunesara, 2020).

Depression

Various studies have shown that depressive symptoms are of more prevalence during adolescence (Zhang, Yan, Zhao, & Yaun, 2015). Considering this predisposition combined with the decrease of face-to-face communication and increase in social media use that followed the stay-at-home order, it is no surprise that the population of adolescents with depressive symptoms is on the rise (Heller, 2016). Also contributing to this rise is the lack of social support that was available during the stay-at-home order. Studies have shown that the less social support perceived by an adolescent, the more likely they are to endure depressive symptoms (Zhang, Yan, Zhao, & Yaun, 2015). In addition, the amount of perceived stress that students are under causes them to be more susceptible to depression symptoms. During the pandemic, it was noted that nearly 50% of adolescents surveyed felt they were experiencing higher perceived stress than before the stay-at-home order. 31% of those surveyed were determined to suffer from depression (Aiyer, Surani, Gill, Ratnani, and Sunesara, 2020).

Depression is a medical illness that can cause persistent feelings of sadness and loss of interest. This disorder can also manipulate an individual's mood or physical functions, and it has also been known to affect growth, development, and school performance (Moreh & O'Lawrence,

2016). A study of secondary school students in Hawaii found that students who self-reported depressive symptoms did not have academic success. Another study found that students who self-divulged depressive issues also suffered from concentration issues and had difficulties completing educational tasks. A third analysis revealed that, in students aged thirteen to seventeen, self-reported depression levels were directly related to the student's ability to concentrate and self-learn. These students were also much more likely to have poor intellectual performance compared to their non-depressed peers (Pascoe, Hetrick, and Parker, 2020). From this research, we can conclude that depression and depression symptoms affect a students ability to achieve scholarly success.

Anxiety

Comparatively to depression, anxiety symptoms are immensely common for adolescents and can cause a negative impact on their general well-being, social skills, and academics (Mazzone, Ducci, Scoto, Passaniti, D'Arrigo, & Vitiello, 2007). Due to the fact that adolescence is a time of development that is filled with emotional, physical, and social changes, it is natural for students to experience anxiety (Raising Children, 2022). Prior to the COVID-19 pandemic, it was estimated that 10%-20% of students met the criteria for an anxiety disorder, while during the pandemic the number of students has soared over 30% (Thompson, Robertson, Curtis, & Frick, 2013; Aiyer, Surani, Gill, Ratnani, and Sunesara, 2020). Given their predisposition for anxiety, the uncertainties of the COVID-19 pandemic has caused a great strain on adolescents' emotional health (Camacho-Zuniga, Pego, Escamilla, & Hossini, 2021).

As with depression, anxiety negatively impacts adolescents' daily lives and scholastic success. Research indicates that impaired memory and cognitive function, poor school achievement, and further mental health issues can all result from anxiety. A study of high school

students noted that nearly all students who reported anxiety symptoms that placed them in the anxious range had little academic success. Another study of students aged 8 to 16 found that there was a statistically significant relationship between high levels of self-reported anxiety and low academic performance (Mazzone, Ducci, Scoto, Passaniti, D'Arrigo, & Vitiello, 2007). While students who suffer from depression and anxiety are prone to low intellectual achievement, a student does not need to suffer from a mood disorder to have their learning affected by their mood.

Mood

All aspects of adolescents' academic lives are affected by their mood, for it plays a vital role in their psychological well-being. A study was conducted where an online survey was administered to students on a weekly basis from March 13th to May 8th, 2020. This survey asked various questions about students' emotions and energy levels. One question asked students "In a single word, how did you feel this week?" The researchers found that of the 15 most common feelings only one of them, 'calm,' was a positive emotion. In a similar study conducted during the quarantine brought on by severe acute respiratory syndrome (SARS), researchers found that few students had positive feelings. Ultimately, in times of quarantine the average student did not experience positive emotions (Camacho-Zuniga, Pego, Escamilla, & Hossini, 2021).

Negative emotions, such as the ones noted by students in these studies, are known to lower a student's cognitive ability and can lead to lower academic achievement (Camacho-Zuniga, Pego, Escamilla, & Hossini, 2021). Studies have shown that a negative mood can impair the working memory and, therefore, a student's cognitive accomplishments. It is thought that individuals who are sad may avoid tasks they perceive as scholastically difficult in fear that those tasks will further ruin their mood. Research has also indicated that those who are

experiencing negative moods may have difficulty processing information, which could have a large impact on their retention in school (Liew and Tan, 2016). The converse is also true, for a study of high school students found that the more frequently students had positive emotions during a class the better their academic performance (Pascoe, Hetrick, and Parker, 2020). While negative moods, stress, depression, and anxiety are not new issues for adolescents, the COVID-19 pandemic has added to the emotional burdens of being a teenager (Camacho-Zuniga, Pego, Escamilla, & Hossini, 2021).

Summary

Enforced restrictions, instability, and stress brought on by the COVID-19 pandemic have been detrimental to adolescents' mental health and learning (Aiyer, Surani, Gill, Ratnani, and Sunesara, 2020). With no preparation or training, adolescents were expected to utilize technology that was once only for leisure as learning devices and following along with their education without the direct supervision of a teacher. With the stay-at-home order, students were isolated from friends and loved ones, saw their extracurricular postponed indefinitely, and possibly had to take on extra duties around their households (Garcia & Weiss, 2020; Whitehurst, 2020). Researchers found that amid the stay-at-home order, students reported a majority of negative feelings and emotions and higher levels of perceived stress. During the pandemic, researchers also noted an increase in adolescent mood disorders, including anxiety and depression (Aiyer, Surani, Gill, Ratnani, and Sunesara, 2020). Consistent stress, mood disorders, and negative mood have all been found to impede a student's ability to retain and recall academic material (Liew and Tan, 2016; Mazzone, Ducci, Scoto, Passaniti, D'Arrigo, & Vitiello, 2007; Romeo, 2016). The COVID-19 pandemic, overall, had adverse effects on adolescents and their scholastic performance.

Chapter Three: Methodology

Introduction

The purpose of this study is to research how the COVID-19 pandemic has affected student achievement in Integrated Mathematics II when controlling for 8th Grade Ohio State Test Scores and students' socioeconomic status. This methodology will cover the setting and participants, the procedure utilized to collect data, and the methods which will be used for data processing and analysis for this study. The first section of this chapter will provide a detailed description of the location in which this study is taking place, as well as the demographic information about the participants. This section will also provide background information in relation to the COVID-19 pandemic and the school district participating in this study. Secondly, this chapter will detail the reliability of the tests which were utilized to collect the data for this study. Thirdly, this methodology will deliver information on how the data was collected and provided to the research team. Lastly, this chapter will detail what statistical tests will be used to process and analyze the data in chapter four. This methodology will conclude with a summary.

Setting and Participants

The population for this study consists of Integrated Mathematics II students from Rootstown Local Schools, which is located in Portage County, Ohio. Serving just over 300 students, Rootstown High School is a small school located in a rural community. Nearly 10% of families within the district live below the poverty line, while over 15% of families have food stamp benefits. 92% of the students in the district are white, while the remaining 8% are black, hispanic or latino, or asian (National Center for Education Statistics, 2019). The data in the study only pertains to Rootstown Local Schools, therefore the results will only apply to this school

district, as well. This study will utilize data collected on 117 Integrated Mathematics II students from the 2018-2019 and 2020-2021 school years.

During the 2018-2019 school year, the Integrated Mathematics II students experienced a normal school year within a standard classroom setting. This is dramatically different from their counterparts who completed the same course during the 2020-2021 school year. Due to the COVID-19 pandemic, students' academic lives changed on a near weekly basis. Rootstown Local School adopted a policy which altered the mode of instruction for students based on the level of COVID-19 cases within the surrounding county. The State of Ohio utilized a color-coded system to assess the level of cases in each county. The colors included, in order from least cases to most cases, yellow, orange, red, and purple (Ohio Department of Health. 2021). When Portage County was in the yellow or orange category, a traditional learning model was utilized. Under a red categorization, Rootstown Local Schools transitioned to a Hybrid learning model. Under this model, half of the students attended school in person Mondays and Wednesdays, while the other half attended Tuesdays and Thursdays. All students were remote on Fridays and were expected to complete work remotely when not at school. When Portage County reached the level of purple, Rootstown Local School utilized a complete remote learning model. These colors were updated on a near daily basis, with the school making adjustments on each Thursday. This led to possible learning model changes on up to a weekly basis for these students.

Due to the uncertainties surrounding the COVID-19 pandemic, parents were also given the option for their students to participate in a completely remote learning model. This instructional unit was taught independently of the school and was facilitated through a program known as Jefferson County. This program did not follow the same timeline or structure as the students who were changing learning models based on the rate of COVID-19 infections. This

program was based around students learning from PDF documents, completing online homework assignments, and non-proctored tests. Students who chose the virtual option, also did not have the same access to a classroom teacher compared to their peers who decided to stay “at school.” The virtual students could reach out to the school to schedule a time to work with the building tutor. Overall, the “virtual” and “in-school” pandemic students had a much different experience from each other and in comparison to their pre-pandemic peers.

For these reasons, students who took Integrated Mathematics II during the 2018-2019 school year will be noted as partaking in a pre-pandemic traditional instructional unit, while students from the 2020-2021 school year will be described as participating in a pandemic traditional instructional unit or pandemic virtual instructional unit.

This data will consist of Ohio State Test scores for Integrated Mathematics II from the 2018-2019 and 2020-2021 school years. These same students' 8th Grade Mathematics Ohio State Test scores from the years 2016-2017 and 2018-2019 will also be considered. Ohio’s State Testing Rules Book (2019) provides an overview of the development procedure that the State of Ohio completed when creating these standardized tests. First, committees of Ohio stakeholders approved criteria by which standardized test questions could be written or selected. These questions were then reviewed and approved by a Content Advisory Committee, which consisted of Ohio educators, and a Fairness and Sensitivity Review Committee. After passing each of these approval processes, the questions then underwent field testing in Ohio schools (Ohio Department of Education, 2019).

The State of Ohio also reports the reliability scores for each of the state’s end of course standardized exams in their “Statistical Summaries and Item Analysis Reports,” which are

published twice a year. The reliability scores for the standardized tests utilized in this study are as follows:

- 8th Grade Mathematics (2016-2017): 0.92
- 8th Grade Mathematics (2018-2019): 0.92
- Integrated Mathematics II (2018-2019): 0.92
- Integrated Mathematics II (2020-2021): 0.90

Given that each standardized test in question has a reliability score of 0.90 or greater, it leads to the conclusion that the Ohio State Tests for 8th Grade Mathematics and Integrated Mathematics II are reliable sources of student knowledge (Ohio Department of Education, 2021).

Along with the 8th Grade Test score data, this study will also utilize students' socioeconomic status as a control. To determine students socioeconomic status, Rootstown Local School provided each student with a "Free and Reduced Price School Meals Application" at the start of the school year. Students who qualify for this free or reduced lunch program are subsequently labeled economically disadvantaged. This data may not be completely accurate, for it has been documented that participation in free and reduced lunch programs is generally the highest in elementary school students and decreases with each following year (Harwell and LeBeau, 2010). Research has also found that free and reduced lunch eligibility data may not be a reliable way to determine a student's socioeconomic status. Harwell and LeBeau (2010) state that free and reduced lunch data is often used by educational institutions due to low cost and accessibility, but it does not follow the same specifications as federal poverty guidelines. For these reasons, the socioeconomic status data utilized in this study may not be completely accurate.

Given that this study will be utilizing data which already exists, the sample size for this study is set at 117 participants. A priori was run on a linear multiple regression model to determine the statistical power for this population with an alpha level of 0.05 and a moderate population effect size of 0.15. There will be one tested predictor, instructional unit, and two control predictors, 8th Grade Mathematics Ohio State Test scores and socioeconomic status. The priori test determined that this study will have a statistical power of 0.9855.

Procedure

The data on the 117 participants was collected by Rootstown Local Schools in conjunction with the State of Ohio. Ohio State Tests, or End of Course Exams, are held during the last quarter of the school year and are required of all students taking Integrated Mathematics II, along with a collection of other subjects. These students are tested on their abilities in four categories; Number quantities, equations & expressions, functions, geometry, and probability. Number quantities, equations, and expressions consists of 25% to 33% of the exam, functions are covered in 19% to 24%, geometry receives the largest portion of 30% to 41%, and probability receives the remaining 18% to 22% (Ohio Department of Education, 2018). During students' 8th grade year, the State of Ohio requires that they participate in the 8th Grade Mathematics Ohio State Test, which consists of equations & expressions, functions, geometry, and the number system. Both equations & expressions and functions make up 20% to 29% of the exam, while geometry consists of 28% to 37% and the number system receives the remaining 20% to 25% (Ohio Department of Education, 2018).

During their respective testing windows, the 117 participants completed both the 8th Grade Mathematics and Integrated Mathematics II Ohio State Tests. The State of Ohio also requires students to participate in a test of Integrated Mathematics I, but due to the COVID-19

pandemic students who were enrolled in Integrated Mathematics II during the 2020-2021 school year were exempt from Ohio State Testing the previous year (Ohio Department of Education, 2020). Therefore, the Integrated Mathematics I Ohio State Test could not be utilized as a control for all 117 students, thus the 8th Grade Mathematics Ohio State Testing data will be used.

Students at Rootstown Local Schools complete their Ohio State Tests utilizing a fully online testing application. This allows the State of Ohio to easily collect and score testing materials. Prior to the start of a school year, Rootstown Local Schools receives the overall results of each Ohio State Test from the previous year. Then, as the year progresses, they are sent each student's individual results. The individual results of 117 participants from the 2016-2017 and 2018-2019 8th Grade Mathematics Ohio State Test and the 2018-2019 and 2020-2021 Integrated Mathematics II Ohio State Test will be utilized in this study.

The instructional unit for each participant was determined by the learning environment in which they completed the course Integrated Mathematics II. Participants who took part in the 2016-2017 8th Grade Mathematics and 2018-2019 Integrated Mathematics II Ohio State Tests will be classified as having taken Integrated Mathematics II with a pre-pandemic traditional instructional unit. Those who completed the 2018-2019 8th Grade Mathematics and 2020-2021 Integrated Mathematics II Ohio State Tests are either categorized as having participated in a pandemic traditional instructional unit or a pandemic virtual instructional unit. Those who continued to participate in class at Rootstown High School throughout the school year experienced a pandemic traditional instructional unit, while those who chose to complete their educational experience remotely took part in a pandemic virtual instructional unit.

The 117 participants were also given the opportunity to participate in a free or reduced lunch program based on their parents' financial statuses. This data is collected by Rootstown

Local Schools at the start of each school year. To qualify for free or reduced lunches, a student's caregiver must fill out a "Free and Reduced Price School Meals Application" indicating that they fall below a certain household income. This data is then utilized by Rootstown Local Schools to determine their economically disadvantaged population.

All data that was presented to the research team, including Ohio State Testing data, free and reduced lunch data, and students instructional unit, were cleansed of all identifying material by an administrator of Rootstown Local Schools, ensuring confidentiality, prior to access by the research team. Therefore, no students or student identifying information will be directly involved in this study and, hence, there is no risk to the participants or their privacy. This is further supported by the approval that this study received from Shawnee State University's Institutional Review Board.

Data Processing and Analysis

As stated, this study works to address the following research questions:

Question 1: Is changing the instructional unit, during the COVID-19 pandemic, when controlling for 8th Grade Mathematics Ohio State Test scores and socioeconomic status, a significant predictor of Integrated Mathematics II Ohio state Test scores?

Question 2: Is there a significant difference between instructional units and Integrated Mathematics II Ohio State Test scores, when controlling for 8th Grade Mathematics Ohio State Test scores and socioeconomic status?

Question 3: Is there a significant difference between socioeconomic status and Integrated Mathematics II Ohio State Test scores, when controlling for 8th Grade Mathematics Ohio State Test scores and instructional units?

Question 4: Which has a larger significant effect on Integrated Mathematics II Ohio State Test

scores, type of instructional unit or socioeconomic status, when controlling for 8th Grade Mathematics Ohio State Test scores?

The null and alternative hypothesis for these questions are as follows, respectfully:

Question 1:

H_0: Changing the instructional unit, when controlling for 8th Grade Mathematics Ohio State Test scores and socioeconomic status, will be a significant predictor of Integrated Mathematics II Ohio State Test scores.

H_a: Changing the instructional unit, when controlling for 8th Grade Mathematics Ohio State Test scores and socioeconomic status, will not be a significant predictor of Integrated Mathematics II Ohio State Test scores.

Question 2:

H_0: There is a significant difference between instructional units and Integrated Mathematics II Ohio State Test scores, when controlling for 8th Grade Mathematics Ohio State Test scores and socioeconomic status.

H_a: There is not a significant difference between instructional units and Integrated Mathematics II Ohio State Test scores, when controlling for 8th Grade Mathematics Ohio State Test scores and socioeconomic status.

Question 3:

H_0: There is a significant difference between socioeconomic status and Integrated Mathematics II Ohio State Test scores, when controlling for 8th Grade Mathematics Ohio State Test scores and instructional units.

H_a: There is not a significant difference between socioeconomic status and Integrated

Mathematics II Ohio State Test scores, when controlling for 8th Grade Mathematics Ohio State Test scores and instructional units.

Question 4:

H_0: Type of instructional unit has a larger significant effect on Integrated Mathematics II Ohio State Test scores than socioeconomic status, when controlling for 8th Grade Mathematics Ohio State Test scores.

H_a: Type of instructional unit does not have a larger significant effect on Integrated Mathematics II Ohio State Test scores than socioeconomic status, when controlling for 8th Grade Mathematics Ohio State Test scores.

This study will first utilize descriptive data, such as means, medians, standard deviation, ranges, and boxplots, to describe the instructional units, Integrated Mathematics II Ohio State Test scores, and 8th Grade Mathematics Ohio State Test scores. A table will be created to display the frequency of students in each instructional unit, along with the mean and standard deviation for the Integrated Mathematics II Ohio State Test scores and 8th Grade Ohio State Test scores for each instructional unit. A similar table will be utilized to break down the frequency, means, and standard deviation of Integrated Mathematics II Ohio State Test scores and 8th Grade Mathematics Ohio State Test scores.

The research team will then go on to run the appropriate statistical tests to answer the research questions. Question 1 consists of one independent variable, instructional unit, one dependent variable, Integrated Mathematics II Ohio State Test Scores, and two control variables, socioeconomic status and 8th Grade Ohio State Test scores. Therefore, a multiple regression model will be utilized to determine if the instructional unit is a significant predictor of Integrated Mathematics II Ohio State Test scores when controlling for 8th Grade Mathematics Ohio State

Test scores and socioeconomic status. In utilizing this statistical method, the research team will first check all necessary assumptions, including independence, normality, equal variances, and multicollinearity (Osborne, 2002). The research team will utilize the Durbin-Watson Test to verify independence and the Shapiro's Test to assess normality. Normality will also be verified utilizing plots, which will additionally be utilized to determine equal variances. Multicollinearity will be verified by examining Variance Inflation Factors. Once all assumptions are tested, then the multiple regression analysis will be performed. Plotts utilized multiple regression analysis on his study which compared Superintendent longevity and student achievement (Plotts, 2011).

Research questions 2 through 4 are closely related and their methods of analysis will be similar. Question 2 has one independent variable, instructional unit, one dependent variable, Integrated Mathematics II Ohio State Test scores, and 2 control variables, 8th Grade Mathematics Ohio State Test scores and socioeconomic status. Question 3 also has one independent variable, socioeconomic status, one dependent variable, Integrated Mathematics II Ohio State Test scores, and 2 control variables, 8th Grade Mathematics Ohio State Test scores and instructional unit. Lastly, question 4 has two independent variables, instructional unit and socioeconomic status, one dependent variable, Integrated Mathematics II Ohio State Test scores, and one control variable 8th Grade Mathematics Ohio State Test scores.

An ANCOVA model will allow the research team to determine statistically significant differences between variables, after controlling for the control variable(s). This statistical method was utilized in a study which researched the effects of instructional time configuration and social studies accountability test results, where poverty was used as a control variable (Volger, Schramm, Allen, and Parler, 2020). Prior to conducting an ANCOVA analysis for questions 2-4, the research team will test all necessary assumptions, including independence, equal variances,

and normality. Levene's Test of Homogeneity of Variance will be used to determine equal variances, Shapiro Wilks Test will be utilized to investigate normality, and, lastly, a regression slopes plot will be used to check independence.

Summary

This methodology has provided an explanation of the setting and participants, the procedure utilized to collect data, and the methods which will be used when processing and analyzing the data for this study. Chapter three began with providing background information on Rootstown Local Schools and the community which surrounds it. This chapter then went on to discuss the instruments that were utilized in the data collection process and their reliability. This led to a discussion of how the data for this study was collected and cleansed prior to access by the research team. There is no risk to students or their privacy, for no students are interacting directly with the research team, and any personal identifiers were cleansed prior to the research team gaining access to the data. The criteria on which instructional units were assigned to participants was also detailed in this chapter. Students who were enrolled in Integrated Mathematics II prior to the COVID-19 pandemic have been labeled as participating in a Pre-Pandemic Traditional instructional unit, while those who took Integrated Mathematics II during the pandemic have taken part in a Pandemic Traditional or Pandemic Virtual instructional unit. Lastly, this methodology detailed the statistical methods which will be utilized in chapter four to process and analyze the data provided by Rootstown Local Schools.

Chapter Four: Results

Introduction

In this chapter, the results of this research study will be presented. The purpose of this study is to determine how the COVID-19 pandemic has affected student achievement in Integrated Mathematics II when controlling for 8th Grade Ohio State Test Scores and students' socioeconomic status. Three instructional units will be considered; Traditional, Pandemic-Traditional, and Pandemic-Virtual. Students who participated in the Traditional instructional unit were enrolled in Integrated Math II prior to the COVID-19 pandemic, while the students who participated in the Pandemic-Traditional and Pandemic-Virtual instructional units were enrolled in the same class during the pandemic. The research questions for this study are:

Question 1: Is changing the instructional unit, during the COVID-19 pandemic, when controlling for 8th Grade Mathematics Ohio State Test scores and socioeconomic status, a significant predictor of Integrated Mathematics II Ohio state Test scores?

Question 2: Is there a significant difference between instructional units and Integrated Mathematics II Ohio State Test scores, when controlling for 8th Grade Mathematics Ohio State Test scores and socioeconomic status?

Question 3: Is there a significant difference between socioeconomic status and Integrated Mathematics II Ohio State Test scores, when controlling for 8th Grade Mathematics Ohio State Test scores and instructional units?

Question 4: Which has a larger significant effect on Integrated Mathematics II Ohio State Test scores, type of instructional unit or socioeconomic status, when controlling for 8th Grade Mathematics Ohio State Test scores?

Data Cleansing

The data utilized in the study was collected and cleansed by an administrator at Rootstown Local Schools. The Integrated Math II Ohio State Test and 8th Grade Math Ohio State Test data was first collected by the State of Ohio and then distributed to Rootstown Local Schools' administration. The socioeconomic data was collected by Rootstown Local Schools through the use of a form titled "Free and Reduced Price School Meals Application," which is distributed to students at the start of each school year. Each student's instructional unit was determined by the school year in which they were enrolled in Integrated Math II. Students who completed Integrated Math II during the 2018-2019 school year were determined to have participated in a Traditional instructional unit, while those who completed the course during the 2020-2021 school year participated in either the Pandemic-Traditional or Pandemic-Virtual instructional unit. No students were excluded from the data set after the research team received the data from the administrator at Rootstown Local Schools.

Materials and Methods

Table 1 presents the mean, median, mode and standard deviation for all participants' Integrated Math II and 8th Grade Math Ohio State Test Scores.

Table 1.
Mean, Median, Mode, and Standard Deviation for Participant Scores by Ohio State Test

Ohio State Test	Mean	Median	Mode	St. Dev.
Integrated Math II	687.67	686	155	26.22
8th Grade Math	707.50	706	116	21.50

The participants in the Pandemic-Traditional instructional unit (N = 48) had the highest mean Ohio State Test score for both Integrated Math II (M = 695.13, SD = 31.13) and 8th Grade

Math (M = 708.44, SD = 23.49), while the participants in the Pandemic-Virtual instructional unit had the lowest mean Ohio State Test score for both Integrated Math II (M = 673.44, SD = 24.66) and 8th Grade Math (M = 706.28, SD = 17.93). Table 2 presents the frequencies, means, and standard deviations for each Ohio State Test based on instructional unit.

Table 2.
Frequencies, Means, and Standard Deviations for Participant Scores by Instructional Unit

Instructional Unit	Frequency	Int Math II OST Mean(SD)	Math 8 OST Mean(SD)
Traditional	51	685.67 (18.63)	707.04 (21.03)
Pandemic-Traditional	48	695.13 (31.13)	708.44 (23.49)
Pandemic-Virtual	18	673.44 (24.66)	706.28 (17.93)

The breakdown of participants according to socioeconomic status was economically disadvantaged (N = 29) and not economically disadvantaged (N = 88). The not economically disadvantaged students who participated in the Pandemic-Traditional instructional unit (N = 39) had the highest mean Integrated Math II Ohio State Test score (M = 697.67, SD = 33.50), while the economically disadvantaged students who participated in the Pandemic-Virtual instructional unit (N = 5) had the lowest mean Integrated Math II Ohio State Test score (M = 654.80, SD = 14.31). The economically disadvantaged students who participated in the Pandemic-Virtual instructional unit (N = 5) also had the lowest mean 8th Grade Math Ohio State Test scores (M = 705.40, SD = 8.08), while the economically disadvantaged students who participated in the Traditional instructional unit (N = 15) had the highest mean 8th Grade Math Ohio State Test score (M = 710.33, SD = 26.69). Table 3 presents the frequencies, mean, and standard deviations for each Ohio State Test based on instructional unit and socioeconomic status.

Table 3.
Frequencies, Means, and Standard Deviations for Participant Scores by SES and Instructional Unit

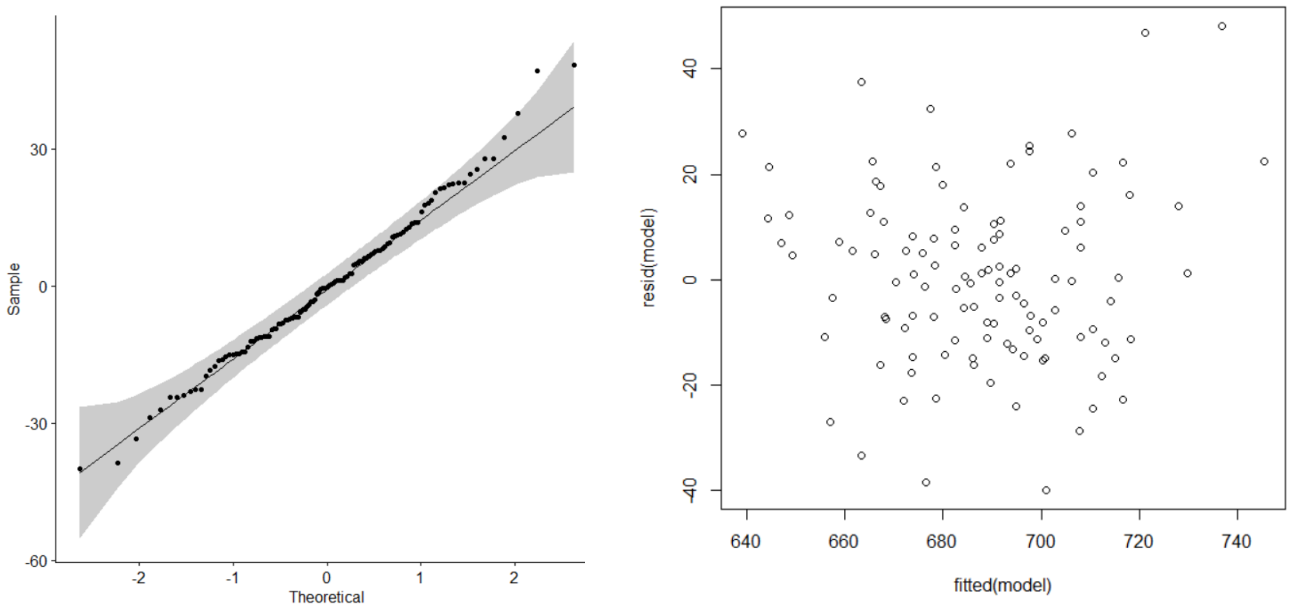
Instructional Unit	SES	Frequency	Int Math II OST Mean(SD)	Math 8 OST Mean(SD)
Traditional	Not Economically Disadvantaged	36	685.22 (15.93)	705.67 (18.45)
Traditional	Economically Disadvantaged	15	686.73 (24.57)	710.33 (26.69)
Pandemic-Traditional	Not Economically Disadvantaged	39	697.67 (33.50)	708.31 (25.06)
Pandemic-Traditional	Economically Disadvantaged	9	684.11 (13.89)	709.00 (16.09)
Pandemic-Virtual	Not Economically Disadvantaged	13	680.62 (24.35)	706.62 (20.81)
Pandemic-Virtual	Economically Disadvantaged	5	654.80 (14.31)	705.40 (8.08)

Data Analysis

Question 1

A Multiple Regression Model was run to determine if changing the instructional unit, during the COVID-19 pandemic, when controlling for 8th Grade Mathematics Ohio State Test scores and socioeconomic status, is a significant predictor of Integrated Mathematics II Ohio state Test scores. There are no cases of missing data, so the results were calculated on the full sample data, $n = 117$. The assumptions of independence, normality, equal variances, and multicollinearity were assessed and no concerns were found. Independence was verified using the Durbin-Watson test; D-W Statistic = 1.98, p = .80. Shapiro's test for normality revealed no concerns; W = 0.990, p = .58. Additional plots that were used to check the normality and equal variance assumption are presented in Chart 1. Multicollinearity was examined using Variance Inflation Factors, which ranged from 1.00 (8th Grade Math Scores) to 1.16 (Pandemic-Traditional instructional unit).

Figure 1.
Plots for Normality and Equal Variance Assumptions - Question One



Hypothesis 1 stated: Changing the instructional unit, when controlling for 8th Grade Mathematics Ohio State Test scores and socioeconomic status, will be a significant predictor of Integrated Mathematics II Ohio State Test scores. To test this hypothesis a multiple regression model was run to determine if the instructional unit is a significant predictor for Integrated Math II Ohio State Test Scores when comparing a Traditional instructional unit to a Pandemic-Traditional instructional unit or a Pandemic-Virtual instructional unit. This model found that the instructional unit, 8th Grade Math Ohio State Test scores, and socioeconomic status were all significant predictors of Integrated II Math Ohio State Test Scores. A significant regression equation was found utilizing these predictor variables ($F(4, 112) = 43.67$, $p < .001$), with an $R^2 = 0.61$ and adjusted-$R^2 = 0.60$. Table 4 presents the standard error, t-value, and p-value for each variable.

Table 4.
Summary of Model - Question One

Variable	Estimate	Standard Error	t-value	p-value
Intercept	71.97	51.04	1.41	.161
Pandemic Traditional	7.15	3.38	2.12	.037
Pandemic Virtual	-11.73	4.57	-2.56	.012
$SES_{\text{Economically Disadvantaged}}$	-10.23	3.60	-2.84	.005
8th Grade Math OST	0.87	0.07	12.09	< 2e-16

The estimates determine how much Integrated Math II Ohio State Test scores increase or decrease compared to the reference group. Hence, a student who participated in the Pandemic-Traditional instructional unit scored 7.15 points higher, on average, on the Integrated Math II Ohio State Test than a student who participated in the Traditional instructional unit. A student who participated in the Pandemic-Virtual instructional unit scored 11.73 points less, on average, on the Integrated Math II Ohio State Test than a student who participated in the Traditional instructional unit. An economically disadvantaged student scored 10.23 points less, on average, on the Integrated Math II Ohio State Test than a student who is not economically disadvantaged. The instructional unit a student participated in while enrolled in Integrated Math II is a significant predictor of Integrated Math II Ohio State Test Scores, with p-values < .05. The results of the ANOVA are presented in Table 5. Hence, the instructional unit that a student participated in while enrolled in Integrated Math II, when controlling for socioeconomic status and 8th Grade Math Ohio State Test scores, is a significant predictor of Integrated II Ohio State Test scores. Using G*Power, a post hoc power analysis indicates a high achieved power of 0.95.

Table 5.
Summary of ANOVA - Question One

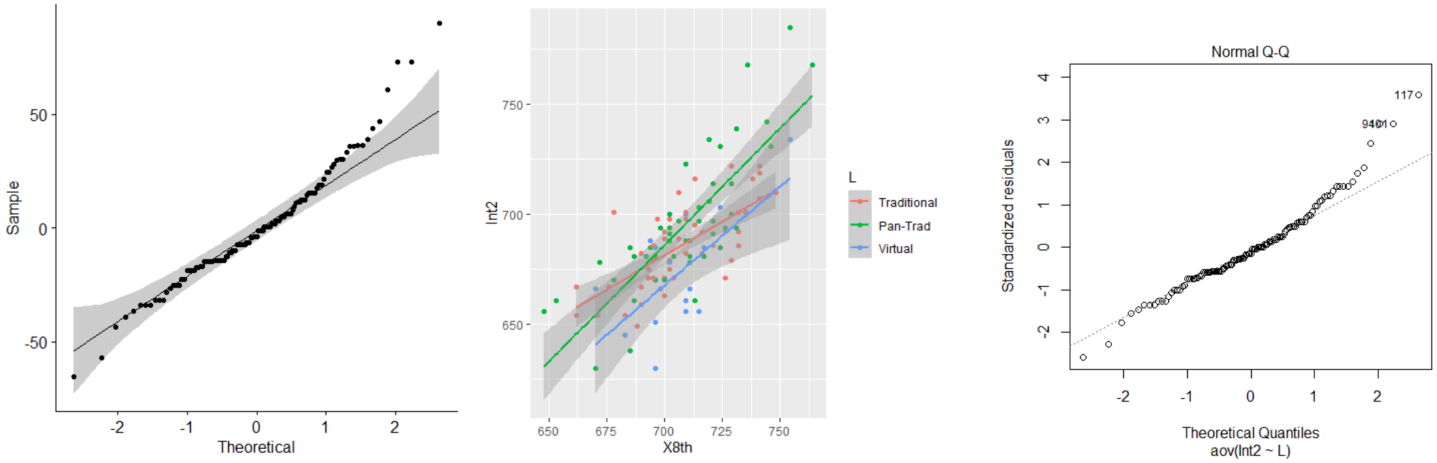
	Df	Sum Sq.	Mean Sq.	F	p
Instructional Unit	2	6515	3257	11.709	2.41e-05
SES	1	1446	1446	5.197	.0245
8th Grade Math OST	1	40632	40632	146.057	< 2e-16
Residuals	112	31158	278	—	—

Question 2

An analysis of covariance, ANCOVA, model was run to determine if there is a significant difference between instructional units and Integrated Math II Ohio State Test scores, when controlling for 8th Grade Mathematics Ohio State Test scores and socioeconomic status. There are no cases of missing data, so the results were calculated on the full sample data, $n = 117$. The assumptions of independence, normality, homogeneity of regression slopes, and equal variances were assessed and one concern was reported. Normality was checked utilizing the Shapiro-Wilk normality test, which revealed no concerns; $W = 0.962$, $p = .002$. Normality was also verified through the use of plots, which are presented in Chart 2. Equal variance was assessed, and no concerns were found, using Levene's Test; $F(2, 114) = 1.92$, $p = .1512$. This was also verified through the use of plots, which are presented in Chart 2. When testing the homogeneity of regression slopes, the interaction effect of socioeconomic status and instructional unit was not statistically significant, $F(2, 111) = 1.86$, $p = 0.16$, which indicates no concern for homogeneity of regression slopes. However, the interaction effect of 8th Grade Math Ohio State Test scores and instructional units were statistically significant, $F(2, 11) = 4.22$, $p < .05$, which indicates a violation of homogeneity of regression slopes. Due to the fact that this is an observational study and not an experiment, the research team will be keeping 8th Grade Math Ohio State Test score

data as a covariant, as it will still help the model to estimate the real relationship between Integrated Math II Ohio State Test scores and instructional unit more accurately (Grace-Martin, 2012). Independence between socioeconomic status and instructional units can be assumed, $F(2, 114) = 0.795$, $p = 0.454$. Independence can also be assumed between 8th Grade Math Ohio State Test scores and instructional units, $F(2, 114) = 0.085$, $p = 0.918$.

Figure 2.
Plots for Normality, Equal Variances, Homogeneity of Regression Slopes Assumptions - Question Two



Hypothesis 2 stated: There is a significant difference between instructional units and Integrated Mathematics II Ohio State Test scores, when controlling for 8th Grade Mathematics Ohio State Test scores and socioeconomic status. An ANCOVA test was run to test this hypothesis, and after adjusting for the covariates, socioeconomic status and 8th Grade Math Ohio State Test scores, there was significant difference between the three instructional units on the Integrated Math II Ohio State Test scores, $F(2, 112) = 11.709$, $p < .001$, partial-$\eta^2 = 0.17$. There was a strong relationship between 8th Grade Math Ohio State Test scores and Integrated Math II Ohio State Test scores, $F(1, 112) = 143.18$, $p < .001$, partial-$\eta^2 = 0.56$. Both the effect sizes for the instructional unit and 8th Grade Math Ohio State Test scores indicate a large effect size. There was also a significant relationship between socioeconomic status and Integrated Math II

Ohio State Test scores, $F(1, 112) = 8.072$, $p < .01$, partial-$\eta^2 = 0.067$. The effect size for socioeconomic status indicates a small to medium effect size. Data from the ANCOVA test is displayed in Table 6. Using G*Power, a post hoc power analysis indicates a high achieved power of 0.99. A Tukey post-hoc analysis was run and the results are presented in Table 7.

Table 6.
Summary of ANCOVA - Question Two

	Df	Sum Sq.	Mean Sq.	F	p
Instructional Unit	2	6515	3257	11.709	2.114e-05
8th Grade Math OST	1	39832	39832	143.181	< 2.2e-16
SES	1	2246	2246	8.072	.005
Residuals	112	31158	278	—	—

Table 7.
Tukey Post-Hoc - Question Two

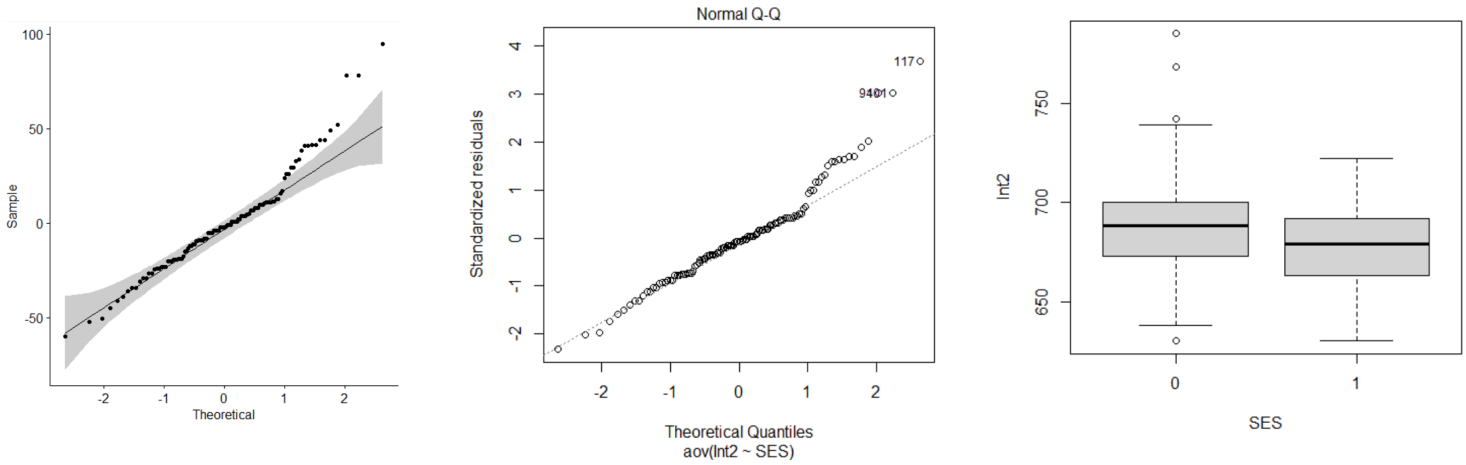
	Estimate	t-value	p-value	95% CI
Pandemic-Traditional == Traditional	7.148	2.116	.0892	(-0.848, 15.144)
Virtual == Traditional	-11.725	-2.564	.0303	(-22.551, -0.900)
Virtual == Pandemic-Traditional	-18.873	-4.081	< .001	(-29.820, -7.927)

Question 3:

An ANCOVA model was run to determine if there is a significant difference between socioeconomic status and Integrated Mathematics II Ohio State Test scores, when controlling for 8th Grade Mathematics Ohio State Test scores and instructional unit. The ANCOVA will be run over the entire data set, n = 117, since there are no cases of missing data. Independence, normality, homogeneity of regression slopes, and equal variances were all checked with no concerns. The Shapiro-Wilk normality test revealed no concerns; $W = 0.952$, $p < .001$. Plots

were also used to verify normality and are presented in Chart 3. Levene's Test was used to verify equal variance with no concerns; F(1,115) = 0.061, p = .806. Equal variance was also confirmed through the use of plots, which are presented in Chart 3. The interaction effect of socioeconomic status and instructional unit, when testing the homogeneity of regression slope, was not statistically significant, F(2,111) = 1.861, p = .160, which indicated no concern for homogeneity of regression slopes. Similarly, the interaction effect of socioeconomic status and 8th Grade Math Ohio State Test scores, when testing the homogeneity of regression slope, was not statistically significant, F(1,113) = 0.917, p = .340, which indicated no concern for homogeneity of regression slopes. Independence between socioeconomic status and instructional units can be assumed, F(2, 114) = 0.795, p = 0.454. Independence can also be assumed between 8th Grade Math Ohio State Test scores and socioeconomic status, F(1, 115) = 0.205, p = 0.651.

Figure 3.
Plots for Normality, Equal Variances, Homogeneity of Regression Slopes Assumptions - Question Three



Hypothesis 3 stated: There is a significant difference between socioeconomic status and Integrated Mathematics II Ohio State Test scores, when controlling for 8th Grade Mathematics Ohio State Test scores and instructional units. An ANCOVA model was run to test this hypothesis, and after adjusting for the covariates, instructional units and 8th Grade Math Ohio

State Test scores, there was a significant difference between socioeconomic status on the Integrated Math II Ohio State Test scores, $F(1, 112) = 7.291$, $p < .01$, partial-$\eta^2 = 0.061$. There was a strong relationship between 8th Grade Math Ohio State Test scores and Integrated Math II Ohio State Test scores, $F(1, 112) = 146.057$, $p < .001$, partial-$\eta^2 = 0.57$ and between instructional units and Integrated Math II Ohio State Test scores, $F(2, 112) = 10.662$, $p < .001$, partial-$\eta^2 = 0.16$. The effect size for socioeconomic status indicates a small to medium effect size, while the effect sizes of the instructional unit and 8th Grade Math Ohio State Test scores indicate a large effect size. Data from the ANCOVA test is displayed in Table 8. Data from the ANCOVA test is displayed in Table 6. Using G*Power, a post hoc power analysis indicates a medium achieved power of 0.78. A Tukey post-hoc analysis was run and the results are presented in Table 9.

Table 8.
Summary of ANCOVA - Question Three

	Df	Sum Sq.	Mean Sq.	F	p
SES	1	2028	2028	7.291	.008
Instructional Units	2	5932	2966	10.662	5.77e-05
8th Grade OST Score	1	40632	40632	146.057	< 2e-16
Residuals	112	31158	278	—	—

Table 9.
Tukey Post-Hoc - Question Three

	Estimate	t-value	p-value	95% CI
Economically Disadvantaged == Not Economically Disadvantaged	-10.23	-2.841	.00534	(-17.36, -3.096)

Question 4:

Two ANCOVA models were run to determine if the instructional unit or socioeconomic status has a larger significant effect on Integrated Mathematics II Ohio State Test scores, when controlling for 8th Grade Mathematics Ohio State Test scores. The ANCOVAs will be run over the entire data set, n = 117, since there are no cases of missing data. Independence, normality, homogeneity of regression slopes, and equal variances were all checked for both models, and one concern was reported. The Shapiro-Wilk normality test of both the instructional unit model ($W = 0.962$, $p < .01$) and socioeconomic status model ($W = 0.952$, $p < .01$) revealed no concerns. Plots were also used to verify normality and are presented in Chart 4 and 5. Levene's Test was used to verify equal variance between Integrated Math II Ohio State Test scores and instructional unit ($F(2,114) = 1.92$, $p = .151$) and between Integrated Math II Ohio State Test scores and socioeconomic status ($F(1,115) = 0.061$, $p = .806$), with no concerns. Equal variances were also confirmed through the use of plots, which are presented in Charts 4 and 5. The interaction effect of socioeconomic status and 8th Grade Math Ohio State Test scores, when testing the homogeneity of regression slope, was statistically significant, $F(2, 111) = 4.222$, $p < .05$, which indicates a violation of homogeneity of regression slopes. As stated under questions 2, since this is an observational study and not an experiment, the research team will be keeping 8th Grade Math Ohio State Test score data as a covariant (Grace-Martin, 2012). The interaction effect of socioeconomic status and 8th Grade Math Ohio State Test scores, when testing the homogeneity of regression slope, was not statistically significant, $F(1,113) = 0.917$, $p = .340$, which indicated no concern for homogeneity of regression slopes. Independence between instructional units and 8th Grade Math Ohio State Test scores can be assumed, $F(2, 114) = 0.085$, $p = .918$.

Independence can also be assumed between socioeconomic status and 8th Grade Math Ohio State Test scores, $F(1, 115) = 0.205$, $p = .651$.

Figure 4.

Plots for Normality, Equal Variances, Homogeneity of Regression Slopes Assumptions - Instructional Unit - Question Four

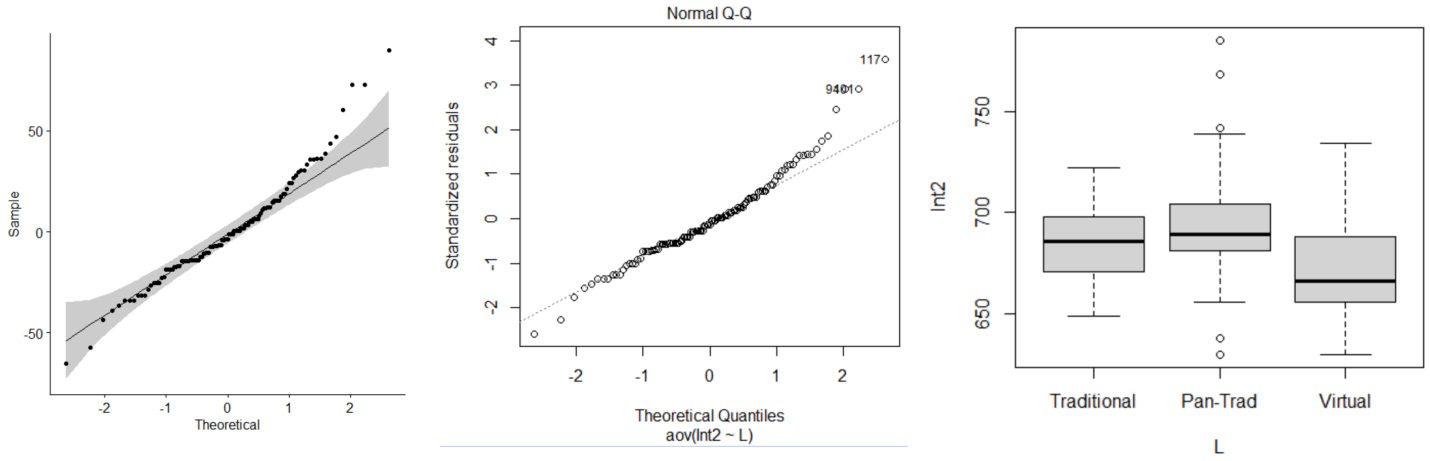
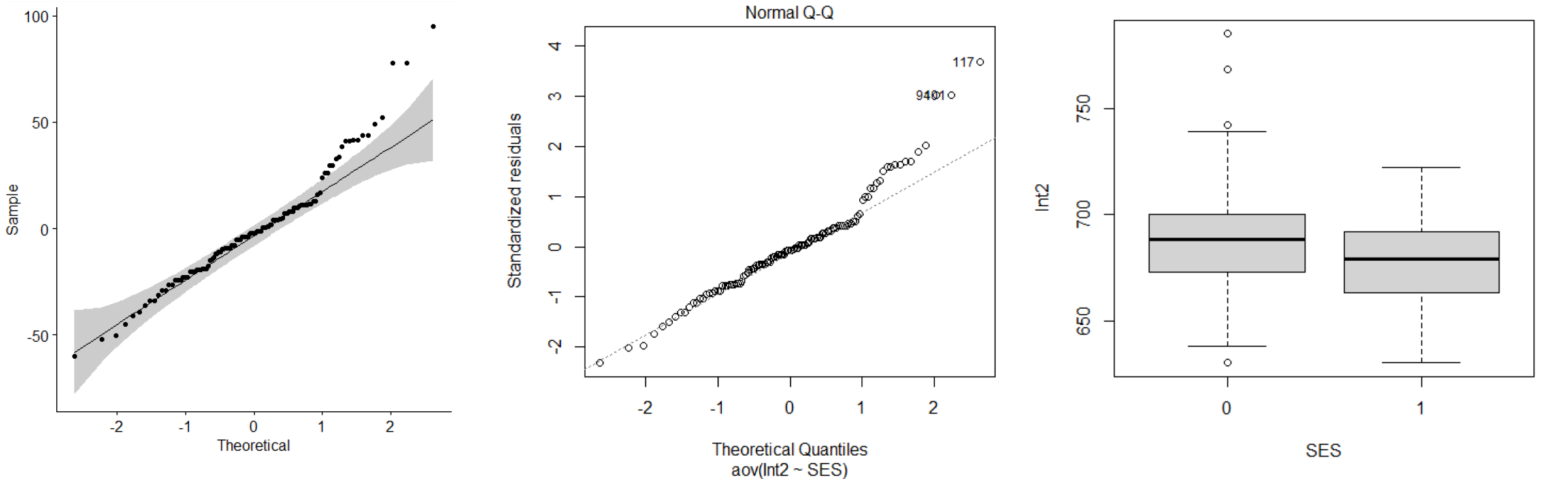


Figure 5.

Plots for Normality, Equal Variances, Homogeneity of Regression Slopes Assumptions - Socioeconomic Status - Question Four



Hypothesis 4 stated: Type of instructional unit has a larger significant effect on Integrated Mathematics II Ohio State Test scores than socioeconomic status, when controlling for 8th Grade Mathematics Ohio State Test scores. Two ANCOVA models were run to test this hypothesis, and after adjusting for the covariate, 8th Grade Math Ohio State Test scores, there was a higher

significant effect of instructional unit on the Integrated Math II Ohio State Test scores, $F(2, 113) = 11.02$, $p < .001$, partial-$\eta^2 = 0.16$, then socioeconomic status on Integrated Math II Ohio State Test scores, $F(1, 114) = 6.442$, $p < .05$, partial-$\eta^2 = 0.05$. The effect size for socioeconomic status indicates a small to medium effect size, while the effect size of the instructional unit indicates a large effect size. Data from both the ANCOVA tests are displayed in Table 10 and 11. Using G*Power, a post hoc power analysis indicates a high and medium achieved power of 0.99 and 0.69, respectively. The results of a Tukey post-hoc analysis are presented in Table 12 and 13.

Table 10.
Summary of ANCOVA - Instructional Units - Question Four

	Df	Sum Sq.	Mean Sq.	F	p
Instructional Units	2	6515	3257	11.02	4.25e-05
8th Grade OST Score	1	39832	39832	134.75	< 2e-16
Residuals	113	33403	296	—	—

Table 11.
Summary of ANCOVA - Socioeconomic Status - Question Four

	Df	Sum Sq.	Mean Sq.	F	p
SES	1	2028	2028	6.442	.0125
8th Grade OST Score	1	41827	41827	132.841	< 2e-16
Residuals	114	35895	315	—	—

Table 12.
Tukey Post-Hoc - Instructional Units - Question Four

	Estimate	t-value	p-value	95% CI
Pandemic-Traditional == Traditional	8.252	2.386	.0476	(0.0732, 16.431)
Virtual == Traditional	-11.565	-2.453	.0403	(-22.711, -0.419)
Virtual == Pandemic-Traditional	-19.817	-4.168	< .001	(-31.060, -8.575)

Table 13.
Tukey Post-Hoc - Socioeconomic Status - Question Four

	Estimate	t-value	p-value	95% CI
Economically Disadvantaged == Not Economically Disadvantaged	-11.492	-3.022	.0031	(-19.026, -3.959)

Summary

This chapter presents the results and data analysis. The data utilized in this study was collected by the State of Ohio and Rootstown Local Schools. Both Integrated Math II and 8th Grade Math Ohio State Test data were first collected by the State of Ohio and then reported to Rootstown Local Schools. Socioeconomic data was collected by Rootstown Local School utilizing a free and reduced lunch application. Lastly, the instructional unit data was based on which year the students were enrolled in integrated math II. Hypothesis testing was used for a total of four hypotheses. A Multiple Regression Model was run to determine if changing the instructional unit, during the COVID-19 pandemic, when controlling for 8th Grade Mathematics Ohio State Test scores and socioeconomic status, is a significant predictor of Integrated Mathematics II Ohio state Test scores. Four ANCOVA tests were run. The first test was run to determine if there is a significant difference between instructional units and Integrated Math II Ohio State Test scores, when controlling for 8th Grade Mathematics Ohio State Test scores and socioeconomic status. Secondly, an ANCOVA was run to determine if there is a significant

difference between socioeconomic status and Integrated Mathematics II Ohio State Test scores, when controlling for 8th Grade Mathematics Ohio State Test scores and instructional unit. Lastly, two ANCOVA tests were run to determine if the instructional unit or socioeconomic status has a larger significant effect on Integrated Mathematics II Ohio State Test scores, when controlling for 8th Grade Mathematics Ohio State Test scores. A post hoc analysis was also run on each test. All four hypotheses were not rejected. The next chapter will further summarize and discuss the results of this study.

Chapter Five: Summary

Introduction

This chapter presents the summary of the results presented in chapter four and recommendations based on the findings of this study, which was designed to determine how the COVID-19 pandemic affected Integrated Mathematics II Ohio State Test scores for students at Rootstown Local Schools. The recommendations given can be pursued by researchers, schools districts, colleges and universities, and governing bodies. This study was conducted utilizing data from 117 students who completed Integrated Mathematics II while enrolled in Rootstown Local Schools. Of those 117 students, 51 completed Integrated Math II prior to the pandemic, 48 completed Integrated Math II with their normal classroom teacher during the pandemic, and 18 completed Integrated Math II virtually without the support of a classroom teacher during the pandemic. Based on data collected by Rootstown Local Schools, 29 of the 117 students were considered economically disadvantaged. This chapter will discuss the differences found between the test scores of each instructional unit and between economically disadvantaged and non-economically disadvantaged students.

Implications

Statement of the Problem: How has the COVID-19 pandemic affected students academically? Despite students heightened perceived levels of stress and the existing research on how this can affect student achievement, little research exists detailing the effects of the COVID-19 pandemic on student achievement (Mann, Smith, Kristjansson, Daily, McDowell, and Traywick, 2021).

The research team found that students who participated in student-led virtual learning during the COVID-19 pandemic scored on average 11.73 points lower on the Integrated

Mathematics II Ohio State Test than their peers who completed the same course and exam prior to the pandemic. Recent research has found that the COVID-19 pandemic led to profound learning loss throughout the world, due to lockdowns and school closures. This learning loss ranged from a 10 percent loss in the country of Chad and 16 percent in South Sudan. The average three month school closure has been estimated to cause up to a full year of learning loss (Moscoviz and Evans, 2022). As stated previously, this learning loss was most prevalent in this research for those students who participated in the pandemic-virtual instructional unit. On average, the students who were enrolled in Integrated Math II through the Jefferson County online learning platform scored, on average, 11.73 points less on the Integrated Math II Ohio State Test than students who took the class prior to the start of the pandemic. This is further supported by a study conducted by Hong, Liu, Cao, Tai, and Zhao (2022), who found that students who experienced online learning during the COVID-19 lockdown negatively evaluated the online learning which they received.

The students who participated in the pandemic-traditional instructional unit did not show the same learning loss as those who completed the class virtually, when compared to those who took the class prior to the COVID-19 pandemic. The students who experienced the pandemic-traditional instructional unit, on average, scored 7.15 points higher than their peers who were enrolled in Integrated Math II prior to the pandemic. The research team speculates that this is due to the fact that the data from before the pandemic was based on students who had a first year teacher. The greater academic achievement experienced by the pandemic-traditional students is based on the growth that the teacher underwent from year one to year three of their career. This speculation is supported by Henry, Bastian, and Fortner (2011), who found that second year teachers generally see greater student achievement than first year teachers. They go

on to discuss that a similar, but smaller, achievement difference is seen between second and third year teachers. Therefore, it is not unreasonable that, despite the COVID-19 pandemic, the students who had a third year teacher experienced greater academic success than those who had a first year teacher.

Question 1: Is changing the instructional unit, during the COVID-19 pandemic, when controlling for 8th Grade Mathematics Ohio State Test scores and socioeconomic status, a significant predictor of Integrated Mathematics II Ohio state Test scores? The findings show that a student's instructional unit is a significant predictor of their Integrated Math II Ohio State Test scores.

Integration of the Findings with Previous Literature: While educational institutions and governments are interested in quantifying the most successful learning environments for students, there is little empirical evidence that can be utilized to evaluate new and existing instructional units (Byers, Mahat, Liu, Knock, and Imms, 2018). However, current research conducted by Bonem, Fedesco, and Zissimopoulos (2020), has found that the quality of the student-teacher interactions has the largest impact on academic success. The average differences of students' Integrated Mathematics II Ohio State Test scores presented with research question #1 support the findings of Bonem et al. As has been stated, students who participated in the pandemic-virtual instructional unit demonstrated the largest learning loss scoring more than 10 points lower than those students who took Integrated Mathematics II prior to the COVID-19 pandemic. These students participated in a completely student-led online learning model, with no direct guidance from a teacher or tutor. The program was designed for students to read lessons presented in PDFs, complete practice problems, and then test their knowledge with quizzes and exams. Support from a teacher was only provided if a student or caregiver reached out to the

school expressing concern, and then the support was only granted on a weekly basis. At Rootstown High School, the students who were enrolled in virtual learning during the pandemic received the least amount of support from qualified teachers and, mirroring Bonem et al.'s research, performed significantly worse than their peers who chose to continue their education at school on the Integrated Mathematics II Ohio State Test.

On the other hand, the students who participated in the pandemic traditional instructional unit scored, on average, over 7 points higher on the Integrated Mathematics II Ohio State Test than their peers who completed the course prior to the COVID-19 pandemic. As stated previously, the students who engaged in the traditional instructional unit prior to the COVID-19 pandemic were taught by a first year teacher. Research has demonstrated that a teacher's instructional techniques and abilities grow greatly from year one to year two, and that a smaller increase in ability is illustrated from year two to year three of their career (Henry, Bastian, and Fortner, 2011). Despite the challenges of the COVID-19 pandemic, the growth the Integrated Math II teacher experienced from year one to year three of her career led her students to perform better on the Integrated Mathematics II Ohio State Test during the pandemic than her first year of teaching. This again directly supports Bonem et al.'s (2020) claim that the quality of the instructor is more important than the environment in which the learning occurs.

Question 2: Is there a significant difference between instructional units and Integrated Mathematics II Ohio State Test scores, when controlling for 8th Grade Mathematics Ohio State Test scores and socioeconomic status? The research found that there is a statistical significant difference between instructional units and Integrated Mathematics II Ohio State Test scores.

Integration of the Findings with Previous Literature: While there does exist statistically significant differences between instructional units and Integrated Mathematics II Ohio State Test

scores, as explained above, this could have more to do with the supports that exist around the instructional units rather than the instructional units themselves (Bonem, Fedesco, and Zissimopoulos, 2020). This is supported by Altun (2017), who found that a factor which has a great impact on student achievement is teacher commitment. Altun (2017) defines teacher commitment as, "an internal force that drives teachers to invest more time and energy in keeping up involvement in the school." Research further suggests that support from peers, teachers, and parents can lead to higher academic achievement (Wang and Eccles, 2013). The students in this study who took part in the pandemic-virtual instructional unit had little to no support from peers and teachers and academically performed lower than their peers who had these supports, despite their socioeconomic status.

Question 3: Is there a significant difference between socioeconomic status and Integrated Mathematics II Ohio State Test scores, when controlling for 8th Grade Mathematics Ohio State Test scores and instructional units? The research demonstrated that there is a statistically significant difference between socioeconomic status and Integrated Mathematics II Ohio State Test scores.

Integration of the Findings with Previous Literature: Prior to the COVID-19 pandemic, the average Integrated Mathematics II Ohio State Test scores for economically disadvantaged and not economically disadvantaged students were within two points of each other. During the pandemic, economically disadvantaged students' Integrated Mathematics II Ohio State Test scores were on average 13.56 points less for pandemic-traditional students and 25.82 points less for pandemic-virtual students. This suggests that economically disadvantaged students at Rootstown High School did not receive the academic support they needed to be as successful as

their non-economically disadvantaged peers during the COVID-19 pandemic, especially if they chose to complete Integrated Mathematics II virtually.

In chapter two, the research team discussed the new responsibilities that many students faced during the COVID-19 pandemic. Many students were forced to take on extra duties inside and outside of their households, including financially contributing to their family and acting as caregivers for younger siblings. These additional roles were more common within families already facing economic hardship prior to the pandemic (Whitehurst, 2020). Regardless of these extra duties and commitments, economically disadvantaged students may not have had the technology required to successfully engage in online learning. Holzer and Lanich (2020) states that economically disadvantaged K-12 students may have been the most negatively affected group of individuals by the COVID-19 pandemic, and this is demonstrated through this research. Holzer and Lanich (2020) go on to detail the lack of technology that economically disadvantaged students faced at the start of the pandemic and how this could cause them to fall behind their non-economically disadvantaged peers. Lake and Makori (2020) conducted a survey in April of 2020 and found that one in five families felt it was ‘very likely’ to ‘somewhat likely’ that their children would not have proper access to technology to keep up with their school work.

Even if economically disadvantaged students were fortunate enough to have the required technology, many of them did not have the support of caregivers, for they were either forced to continue working outside the home or had to give their main focus to working from home to continue providing for their families (Clemens, Deschamps, & Fegert, 2020). Regardless of their unique situations, researchers at Michigan State University found that, while the majority of students encountered learning loss during remote learning, economically disadvantaged students experienced a greater amount than non-economically disadvantaged peers (Degrow, 2022).

Pearson (2022) supports the research conducted by Michigan State University and, also, reports that tutoring is the most cost effective method for helping these students catch up to their more affluent peers. At Rootstown High School, during the 2020-2021 school year, little to no support was offered to help students catch up outside of their classes and it is reflected in the schools Integrated Mathematics II Ohio State Test scores.

Question 4: Which has a larger significant effect on Integrated Mathematics II Ohio State Test scores, type of instructional unit or socioeconomic status, when controlling for 8th Grade Mathematics Ohio State Test scores? The research found that there was a higher statistically significant effect of the instructional unit than socioeconomic status on Integrated Mathematics II Ohio State Test scores.

Integration of the Findings with Previous Literature: While the economically disadvantaged students at Rootstown High School performed worse than their peers within the same instructional unit, during the COVID-19 pandemic, on the Integrated Mathematics II Ohio State Test, the students who participated in the pandemic-virtual instructional unit produced the worst scores. For instance, the economically disadvantaged pandemic-traditional students scored, on average, more than 13 points less than their non-economically disadvantaged peers, however the non-economically disadvantaged students who participated in the pandemic-virtual instructional unit scored, on average, about 4 points even lower. The largest gap between economically disadvantaged and non-economically disadvantaged students' scores was within the pandemic-virtual instructional unit. As considered in chapter two, for online learning to be successful, students must receive proper training and have access to the necessary technology. As discussed above, many economically disadvantaged families did not have access to the proper technology. Even so, those students who did have access were accustomed to utilizing

technology for leisure activities. Online learning requires students to ignore the distractions that are readily available with internet access. Data from online charter schools has also highlighted the importance of support in the online learning process (Garcia & Weiss, 2020).

Pandemic-virtual students at Rootstown High School were not given the support of a licensed teacher while working remotely during the 2020-2021 school year. Research has also demonstrated that many students, especially those who are economically disadvantaged, most likely did not have support from parents or caregivers either. This is due to parents and caregivers having to focus on work or providing childcare for younger siblings (Clemens, Deschamps, & Fegert, 2020). Virtual students at Rootstown High School were enrolled in Jefferson County's Virtual Learning Academy and offered little to no support from qualified educators. Morin (2022) ascertains that students need more structure and support during virtual learning. She claims that many students relied on the structure and support offered by in-person education to stay focused and keep up with their education. Once students became responsible for their own learning, Morin (2022) continues, many were not prepared to stay organized and focused without support in place. As with in person or virtual school, once students begin to fall behind it can seem like a monumental task to catch up, so students may have found themselves disengaging instead (Morin, 2022).

Implications for Rootstown Local Schools: It is clear in the data that students at Rootstown Local School who participated in the pandemic-virtual instructional unit have fallen behind in mathematics, compared to their other peers. This is especially true for the economically disadvantaged students who completed Integrated Mathematics II virtually. Research suggests that tutoring may be the most cost effective way to help these students to catch up to their higher performing peers (Pearson, 2022). While tutoring for struggling students

was not in place for the 2021-2022 school year, Rootstown Local Schools is taking action in the 2022-2023 school year to offer tutoring opportunities during school hours for students who performed poorly on their Ohio State Tests.

Recommendations

This study revealed that at Rootstown High School, instructional units can be utilized to predict Integrated Mathematics II Ohio State Test scores, the students who participated in virtual education during the pandemic demonstrated the lowest Integrated Mathematics II Ohio State Test scores, and the economically disadvantaged students performed worse on the Integrated Mathematics II Ohio State Test than their non-economically disadvantaged peers. Thus the following recommendations are hereby presented:

Academic Recommendations:

1. Since this study was conducted with a small population and only within one subject area, other research could be conducted to strengthen the results of this study and combat the limitations mentioned in early chapters.
    a. To gain a greater understanding of the results of learning loss caused by the COVID-19 pandemic within the State of Ohio, a similar study could be run utilizing math and language arts Ohio State Test data data from a multitude of districts.
    b. Since the Ohio State Test data only applies to students in Ohio, to gain a greater understanding of the results of learning loss caused by the COVID-19 pandemic throughout the United States, data from a different test, such as the American College Test, or ACT, could be utilized.

2. Since this study was quantitative, a qualitative study could be conducted to strengthen and expand upon the information that was reported in this study. Students and teachers could be surveyed about their feelings surrounding education during the pandemic. Their feelings could then be compared to test scores associated with them. For instance, if a teacher had positive thoughts and feelings about their time teaching in the pandemic, it would be interesting to see if their students' test scores reflect positively.

Practical Recommendations:

3. Broader research supports this study's findings that economically disadvantaged and remote learners have fallen behind their peers (Degrow, 2022).
    a. Research has found that tutoring is possibly the most cost effective way to combat this learning loss (Pearson, 2022). School districts could offer greater tutoring opportunities for struggling students to assist them in catching up with their peers.
    b. The national and state governments could offer monetary support to schools to assist them in hiring qualified tutors to assist these struggling students or to compensate teachers who may take on extra duties outside of their contract hours to offer tutoring.
    c. Colleges and Universities could begin to prepare for students who could benefit from greater remedial support in math and language arts. This could manifest as student tutoring centers on campus or through the creation of remedial courses to prepare students for college math and writing.

Conclusions

Based on the findings detailed in chapter four, four overarching conclusions were drawn. Firstly, prior to the pandemic, economically disadvantaged students in Rootstown Local Schools

were performing at nearly the same level as their more affluent peers on the Integrated Math II Ohio State Test. However, during the COVID-19 pandemic, the achievement gap between these two groups of students widened, especially for those students who were enrolled in Integrated Math II remotely. Secondly, students enrolled in Integrated Math II remotely during the pandemic, regardless of economic status, performed exceptionally worse than those students who continued their education in person. Both of these claims are supported by the results presented by the research team, for a statistically significant relationship was determined between socioeconomic status and Integrated Mathematics II Ohio State Test scores, as well as between instructional units and Integrated Mathematics II Ohio State Test scores. The research team also found that there existed a stronger statistically significant relationship between instructional units and Integrated Mathematics II Ohio State Test scores than between socioeconomic status and Integrated Mathematics II Ohio State Test scores. This is supported by the fact that regardless of socioeconomic status, those students who were enrolled in Integrated Math II virtually performed significantly worse than their peers who completed the class in person.

Thirdly, the growth the Rootstown High School Integrated Math II teacher experienced from year one to year three of teaching could explain the increase in test scores demonstrated by the pandemic-traditional instructional unit. Research has shown that teachers drastically improve from year one to year two of their careers and continue to experience this growth into their third year (Henry, Bastian, and Fortner, 2011). As research continues in this field, the quality of education provided by a teacher will be an important piece of information to consider.

Lastly, Rootstown High School students who completed Integrated Mathematics II virtually are significantly behind their peers and will require extra support in the years to come. As of the 2022-2023 school year, Rootstown Local Schools will be offering opportunities for

students to improve on concepts covered on the Ohio State Tests. Research has found that tutoring may be a cost effective way to combat the learning loss of the COVID-19 pandemic (Pearson, 2022). As listed in the recommendations, colleges and universities may also benefit from offering extra tutoring and remedial education opportunities for their students, if the results of this study are mirrored on a larger scale.

References

Aiyer,A., Surani, S., Gill, Y., Ratnani, I., & Sunesara, S. (2020). Covid-19 Anxiety and Stress Survey (Cass) in High School and College Students Due to the Coronavirus Disease 2019. Chest Journal, 314A. https://journal.chestnet.org/action/showPdf?pii=S0012-3692%2820%2932498-3

Ball, J. (2016). Why Do We Experiment on Rats and Mice for Human Research? ABC 10. https://www.abc10.com/article/news/health/why-do-we-experiment-on-rats-and-mice-for-human-research/103-373516158

Ballotpedia (2020). Documenting Ohio's Path to Recovery from the Coronavirus (COVID-19) Pandemic, 2020-2021. Ballotpedia. https://ballotpedia.org/Documenting_Ohio%27s_path_to_recovery_from_the_coronavirus_(COVID-19)_pandemic,_2020-2021

Ballotpedia (2021). School Responses in Ohio to the Coronavirus (COVID-19) Pandemic. Ballotpedia. https://ballotpedia.org/School_responses_in_Ohio_to_the_coronavirus_(COVID-19)_pandemic

Bangasser, D. A., Shors, T. J. (2010). Critical Brain Circuits at the Intersection Between Stress and Learning. Neuroscience and Biobehavioral Reviews, 34, 1223-1233. http://63.143.39.162/~rcirutge/wp-content/uploads/2011/08/bangasser-critical-circuits-b-w-stress-and-learning.pdf

Camacho-Zuniga, C., Pego, L., Escamilla, J., Hosseini, S. (2021). The Impact of the COVID-19 Pandemic on Students' Feelings at High School, Undergraduate, and Postgraduate Levels. Heliyon, 7(3). https://doi.org/10.1016/j.heliyon.2021.e06465

Clay, J. (2020) Timeline of coronavirus in Ohio. ABC 6. https://abc6onyourside.com/news/local/timeline-of-coronavirus-in-ohio

Clemens V., Deschamps P., Fegert J.M. (2020). Potential effects of "social" distancing measures and school lockdown on child and adolescent mental health. Eur Child Adolesc Psychiatry, 29(6), 739–742. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7245163/

Field, K. (2021) To test or not to test? Educators weigh the value of standardized testing during a pandemic. *The Hechinger Report*. https://hechingerreport.org/to-test-or-not-to-test-educators-weigh-the-value-of-standardized-testing-during-a-pandemic/

Garcia, E., Weiss, E. (2020). COVID-19 and Student Performance Equity, and U.S. Education Policy. Economic Policy Institute. https://www.epi.org/publication/the-consequences-of-the-covid-19-pandemic-for-education-performance-and-equity-in-the-united-states-what-can-we-learn-from-pre-pandemic-research-to-inform-relief-recovery-and-rebuilding/

Gershon, L. (2015). A Short History of Standardized Tests. *JSTOR Daily. https://daily.jstor.org/short-history-standardized-tests/*

Grace-Martin, K. (2012). *When Assumptions of ANCOVA are Irrelevant.* The Analysis Factor. https://www.theanalysisfactor.com/assumptions-of-ancova/

Harwell, M., LeBeau, B. (2010). Student Eligibility for a Free Lunch as an SES Measure in Education Research. *Educational Researcher, 39*(2), 120-131. https://www.jstor.org/stable/27764564?read-now=1&seq=1

Health Matters (2021). Is Social Media Threatening Teens' Mental Health and Well-being?. Columbia University Irving Medical Center. https://www.cuimc.columbia.edu/news/social-media-threatening-teens-mental-health-and-well-being

Heller, R. (2019). Stress Gets Under Your Skin: A Conversation with Emma K. Adam. The Phi Delta Kappan, 103(3), 32-36.https://www.jstor.org/stable/26837679

Henry, G. T., Bastian, K. C., & Fortner, C. K. (2011). Stayers and Leavers: Early-Career Teacher Effectiveness and Attrition. *Educational Researcher*, *40*(6), 271–280. http://www.jstor.org/stable/41238952

Hobson, N. (2018). Why Your Brain on Stress Fails to Learn Properly. Psychology Today. Retrieved March 13, 2021, form https://www.psychologytoday.com/us/blog/ritual-and-the-brain/201804/why-your-brain-stress-fails-learn-properly

Holzer, H. J., Lanich, J. (2020). Students have lost learning due to COVID-19. Here are the economic consequences. Brookings. https://www.brookings.edu/opinions/students-have-lost-learning-due-to-covid-19-here-are-the-economic-consequences/

Hong, J.-C., Liu, X., Cao, W., Tai, K.-H., & Zhao, L. (2022). Effects of Self-Efficacy and Online Learning Mind States on Learning Ineffectiveness during the COVID-19 Lockdown. *Educational Technology & Society*, *25*(1), 142–154. https://www.jstor.org/stable/48647036

Lake, R., Makori, A. (2020). The Digital Divide Among Students During COVID-19: Who has access? Who doesn't?. CRPE. https://crpe.org/the-digital-divide-among-students-during-covid-19-who-has-access-who-doesnt/

Lee J. (2020). Mental health effects of school closures during COVID-19. Lancet Child Adolesc Health, 4(6), 421. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7156240/

Levin, C. (1992). Only a Teacher. *Public Broadcasting Service. https://www.pbs.org/onlyateacher/about.html*

Liew, T. W., & Tan, S.. (2016). The Effects of Positive and Negative Mood on Cognition and Motivation in Multimedia Learning Environment. *Journal of Educational Technology & Society*, *19*(2), 104–115. http://www.jstor.org/stable/jeductechsoci.19.2.104

Mann, M.J., Smith, M.L., Kristjansson, A.L., Daily, S., McDowell, S., Traywick, P. (2021). Our Children Are Not "Behind" Due to the COVID-19 Pandemic, but Our Institutional Response Might Be. *Journal of School Health*, 91(6):447-450.

Mazzone, L., Ducci, F., Scoto, M.C., Passaniti, E., D'Arrigo, V. G., Vitiello, B. (2007). The Role of Anxiety Symptoms in School Performance in a Community Sample of Children and Adolescents. BMC Public Health, 7, 347. https://bmcpublichealth.biomedcentral.com/articles/10.1186/1471-2458-7-347

Moreh, S., O'Lawrence, H. (2016). Common Risk Factors Associated with Adolescent and Young Adult Depression. *Journal of Health and Human Services Administration*, *39*(2), 283–310. http://www.jstor.org/stable/44504679

Morin, A. (2022). 5 Reasons Students Aren't Engaging in Distance Learning. Child Mind Institute. https://childmind.org/article/5-reasons-students-arent-engaging-in-distance-learning/

Moscoviz, L., & Evans, D. K. (2022). Introduction. In *Learning Loss and Student Dropouts during the COVID-19 Pandemic: A Review of the Evidence Two Years after Schools Shut Down* (pp. 1–2). Center for Global Development. http://www.jstor.org/stable/resrep39925.3

Mosley, A. (2020). The Negative Effects of Screen Time for Adults and Children. Valleywise Health. https://blog.valleywisehealth.org/negative-effect-of-screen-time-adults-children

Nagata, J., Cortez, C., Cattle, C. (2022). Screen Time Use AMong US Adolescents During the COVID-19 Pandemic. JAMA Network, 176(1), 94-96. https://jamanetwork.com/journals/jamapediatrics/fullarticle/2785686

National Center for Education Statistics. (2019). *Education Demographic and Geographic Estimates: Rootstown Local School District, OH.* National Center for Education Statistics. https://nces.ed.gov/Programs/Edge/ACSDashboard/3904921

Nicks, M. (2021). Some Northeast Ohio Schools Return to Online Learning in Days Leading up to Winter Break. Cleveland 19 New. cleveland19.com/2021/12/16/some-northeast-ohio-schools-return-online-learning-days-leading-up-winter-break/

Ohio Department of Education. (2017). Ohio Learning Standards: Mathematics Grade 8. *Ohio Department of Education.* https://education.ohio.gov/getattachment/Topics/Learning-in-Ohio/Mathematics/Ohio-s-Learning-Standards-in-Mathematics/MATH-Standards-Grade-8.pdf.aspx?lang=en-US

Ohio Department of Education. (2018). Ohio Grade 8 Mathematics Blueprint. *Ohio Department of Education.* https://oh-ost.portal.cambiumast.com/-/media/project/client-portals/ohio-ost/pdf/2015q4/ohio_math_grade8_blueprint.pdf

Ohio Department of Education. (2018). Ohio Learning Standards: Mathematics 2. *Ohio Department of Education.* https://education.ohio.gov/getattachment/Topics/Learning-in-Ohio/Mathematics/Ohio-s-Learning-Standards-in-Mathematics/MATH-2-Standards.pdf.aspx?lang=en-US

Ohio Department of Education. (2018). Ohio Mathematics 2 Blueprint. *Ohio Department of Education*. https://oh-ost.portal.cambiumast.com/-/media/project/client-portals/ohio-ost/pdf/2015q4/ohio_mathematicsii_blueprint.pdf

Ohio Department of Education. (2019). Ohio's State Tests Rules Book: 2019-2020. *Ohio Department of Education.* https://education.ohio.gov/getattachment/Topics/Testing/Testing-Forms-Rules-and-Committees/Ohio%E2%80%99s-State-Tests-Rules-Book/OhiosStateTestsRulesBook.pdf.aspx?lang=en-US

Ohio Department of Education. (2020). State Testing. *Ohio Department of Education.* https://education.ohio.gov/Topics/Student-Supports/Coronavirus/Additional-Information-on-State-Testing-During-the

Ohio Department of Education (2021). Spring 2021 Testing. *Ohio Department of Education.* https://education.ohio.gov/Topics/Reset-and-Restart/Spring-2021-Testing

Ohio Department of Education. (2021). Statistical Summaries and Item Analysis Reports. *Ohio Department of Education.* https://education.ohio.gov/Topics/Testing/Statistical-Summaries-and-Item-Analysis-Reports

Ohio Department of Health. (2021). COVID-19 Dashboard. *Ohio Department of Health.* https://coronavirus.ohio.gov/dashboards/other-resources/public-health-advisory-system

Orben, A., Tomova, L., Blakemore, S. (2020). The Effects of Social Deprivation on Adolescents Development and Mental Health. The Lancet: Child & Adolescent Health, 4(8), 634-640. https://www.thelancet.com/journals/lanchi/article/PIIS2352-4642(20)30186-3/fulltext

Osborne, J. W. (2002). Four Assumptions of Multiple Regression that Researchers Should Always Test. *Practical Assessment, Research, and Evaluation, 8(2). https://scholarworks.umass.edu/cgi/viewcontent.cgi?article=1111&context=pare*

Pascoe, M. C., Hetrick, S. E., Parker, A. G. (2020). The Impact of Stress on Students in Secondary School and Higher Education. International Journal of Adolescence and Youth, 25(1), 104-112. https://www.tandfonline.com/doi/pdf/10.1080/02673843.2019.1596823

Pearson, H. (2022). COVID derailed learning for 1.6 billion students. Here's how schools can help them catch up. *Nature.* https://www.nature.com/articles/d41586-022-01387-7

Plotts, T. (2011). A Multiple Regression Analysis of Factors Concerning Superintendent Longevity and Continuity Relative to Student Achievement. *Seton Hall University Dissertations and Thesis.* https://scholarship.shu.edu/cgi/viewcontent.cgi?referer=&httpsredir=1&article=1482&context=dissertations

Plumridge, N. (2020). Communication: Online vs. Face-to-Face Interactions. Psychminds. https://psychminds.com/communication-online-vs-face-to-face-interactions/

Raising Children (2022). Anxiety and How to Manage it: Preteens and Teenagers. Raising Children. https://raisingchildren.net.au/pre-teens/mental-health-physical-health/stress-anxiety-depression/anxiety#:~:text=This%20is%20because%20adolescence%20is,these%20changes%2C%20opportunities%20and%20challenges.

Romeo, R. D. (2017). The Impact of Stress on the Structure of the Adolescent Brain: Implications for Adolescent Mental Health. Brain Research, 1654 (Part B), 185-191. https://www.sciencedirect.com/science/article/abs/pii/S0006899316301482

Rosales, J., Walker, T. (2021) The Racist Beginnings of Standardized Testing. *National Education Association.* https://www.nea.org/advocating-for-change/new-from-nea/racist-beginnings-standardized-testing

Salehi, B., Cordero, I., Sandi, C. (2010). Learning Under Stress: The Inverted-U-Shape Function Revisited. Cold Spring Harbor Laboratory Press, 17, 522-530. http://learnmem.cshlp.org/content/17/10/522.full.pdf+html

Sandstrom, H., Huerta, S. (2013). The Negative Effects of Instability on Child Development. Urban Institute. https://www.urban.org/sites/default/files/publication/32721/412908-The-Negative-Effects-of-Instability-on-Child-Development-Fact-Sheet.PDF

Thakur, A. (2020). Mental Health in High School Students as the Time of Covid-19: A Student's Perspective. J Am Acad Child Adolesc Psychiatry, 59(12), 1309-1310. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7448765/

Thomas, T. R. (2021). *A Case Study Exploring the Impact of Trauma-Sensitive Practices on High School Graduation Rates in an Urban Public School* [Doctoral dissertation, Xavier University]. OhioLINK Electronic Theses and Dissertations Center. http://rave.ohiolink.edu/etdc/view?acc_num=xulead1626985861669408

Thompson, E. H., Robertson, P., Curtis, R., & Frick, M. H. (2013). Students with Anxiety: Implications for Professional School Counselors. *Professional School Counseling*, *16*(4), 222–234. http://www.jstor.org/stable/profschocoun.16.4.222

Vogel, S., Schwabe, L. (2016). Learning and Memory Under Stress: Implications for the Classroom. npj Science of Learning, 16011 https://www.nature.com/articles/npjscilearn201611#citeas

Vogler, K. E., Schramm, S., Allan, A., & Parler, J. D. (2020). Using instructional time and race/ethnicity to predict social studies accountability test results. *Journal of Educational Research and Practice, 10,* 199–220. https://doi.org/10.5590/JERAP.2020.10.1.14

Wang, M.T., & Eccles, J. S. (2012). Social Support Matters: Longitudinal Effects of Social Support on Three Dimensions of School Engagement From Middle to High School. *Child Development*, 83(3), 877–895. http://www.jstor.org/stable/23255730

Whitehurst, L. (2020). Teens Struggle to Balance School, Family, Work Amid Covid-19. AP News. https://apnews.com/article/virus-outbreak-ct-state-wire-ap-top-news-il-state-wire-pa-state-wire-a038e5971aa888edf40f7c0bf4c8a65d

Willis, J. (2014). The Neuroscience Behind Stress and Learning. Edutopia. https://www.edutopia.org/blog/neuroscience-behind-stress-and-learning-judy-willis

Zhang, B., Yan, X., Zhao, F. & Yuan, F. (2015). The Relationship Between Perceived Stress and Adolescent Depression: The Role of Social Support and Gender. Social Indicators Research, 123(2), 501-518. https://www.jstor.org/stable/24721616

Appendix A: IRB Approval

Approval for this study was requested from the Institutional Review Board of Shawnee State University. The email correspondence with the IRB chair for Shawnee State University, Dr. Hamilton, approving this study, is collected here.

Banas- IRB Exempt Review Application

Jessica Banas Sun, Oct 24, 2021 at 8:14 PM
To: IRB@shawnee.edu
Cc: ddarbro

To Whom It May Concern,

Attached are all necessary materials for my IRB Exempt Review Application. This includes my NIH training certificate, Research Summary Questions, and completed IRB Exempt Review Application form.

Thank you,

Jessica Banas

Banas- IRB Exempt Review Application

IRB <irb@shawnee.edu>
To: Jessica Banas
Cc: Douglas Darbro

Good evening, Jessica,

I have reviewed your application and approved it. I will send stamped copies to Dr. Darbro through campus mail on Tuesday.

Good luck with your research. Sincerely,
Dr. Hamilton

Appendix B: PHRP Certification

CERTIFICATE

OF COMPLETION

PHRP Online Training, Inc. certifies that

Jessica Banas

has successfully completed the web-based course "Protecting Human Research Participants Online Training."

Date Completed: **2021-08-26** Certification Number: **2870055**

PHRP
Protecting Human
Research Participants
Online Training

Bibliography

Jessica L. Banas

Candidate for the Degree of

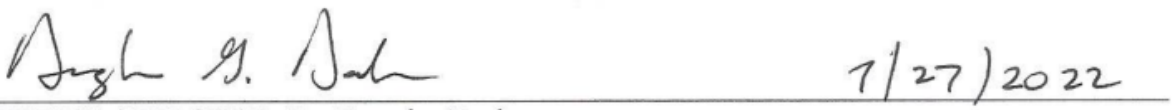
Master of Science, Mathematics

Thesis: A STUDY OF THE IMPACT OF THE COVID-19 PANDEMIC ON INTEGRATED MATHEMATICS II OHIO STATE TEST SCORES

Major Field: Mathematics

Education: Bachelor's of Arts in Adolescent to Young Adult Integrated Mathematics

Completed the requirements for the Masters of Science in Mathematics, Portsmouth, Ohio in July of 2022.



7/27/2022

ADVISER'S APPROVAL: Dr. Douglas Darbro