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Academic Performance in Mathematics of High School Students with Virtual Instruction vs. Face-to-Face Instruction

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Academic Performance in Mathematics of High School Students with Virtual Instruction vs. Face-to-Face Instruction

A Thesis

By

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The thesis entitled "**Academic Performance in Mathematics of High School Students with Virtual Instruction vs. Face-to-Face Instruction**" presented by **Ahmed Dakwar**, a candidate for the degree of **Master of Science in Mathematics,** has been approved and is worthy of acceptance.

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Abstract

The intent of this study was to explore the extent to which the academic performance in mathematics differs between high school students with virtual learning and students with traditional classroom face-to-face learning. The study focused on Tennessee public high schools, and this thesis was a quantitative study. The data were collected from credible Internet sources such as the Tennessee Department of Education website, where the data were made available for the public to use and analyze for research purposes.

A total of 143 high schools located in 58 counties participated in the study. The selection of the sample was done by stratification, and the participating schools were selected from 20 economically disadvantaged counties and 38 economically non-disadvantaged counties. Ultimately, a total of 36 selected schools were located in economically disadvantaged counties and 107 schools were located in economically non-disadvantaged counties.

The two-way ANOVA followed by multi-regression analysis along with the software R were employed to carry out the statistical design and analyze the data. The designated statistical hypotheses were tested at 0.05 significance level. For the two-way ANOVA analysis, two types of instruction and two classifications of economic status were considered for the difference in math proficiency rates. For the multi-regression analysis, 8 independent variables including a covariate, were considered to identify the significant predictors for a valid prediction of the math proficiency rate of students with the virtual instruction method.

The sample size, sampling method, and reviewed literature supported the reliability and validity of the data results obtained from the study. The data showed a significant decline of 9.6028 ± 2.7839 percentage points in the academic performance in mathematics for students with virtual instruction. The data also resulted in a reliable predictive mathematical model with a

coefficient of determination R^2_{Adj} of 0.5518 and two significant predictors for the academic performance in mathematics of high school students with virtual instruction. The explicit predictive model was:

Rate of students achieving proficient academic performance in mathematics of high school students with virtual learning ≈ 5.7383 + 0.51279 × Rate of students achieving proficient academic performance in mathematics of high school students with face-to-face learning − 0.128 × Percentage of people of color constituent.

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Dedication

To my parents Akram and Siham Dakwar

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Chapter 1 - Introductory Chapter

Introduction

This chapter is a brief overview of the background of the study, the question addressed by the study, the significance of the study, the methodology used for collecting and analyzing the data, the limitations of the study, and definitions of the key terms used in the study.

The purpose of the study is to explore the extent to which the academic performance in mathematics differs between high school students with virtual learning and students with traditional classroom face-to-face learning. The scope of the study is to align the study with an established theoretical framework that is specific to teaching and learning theories regardless of the instructional delivery modality used in the process. Virtual learning in high schools was in demand when the country shut down for a number of months due to the COVID-19 pandemic, specifically during the school year 2020-2021.

Background of the Study

This study is to compare the academic performance of high school students in mathematics using virtual delivery instruction with the academic performance of students using the traditional classroom face-to-face instructional delivery method. During the COVID-19 pandemic, high schools had to convert from a face-to face setting to a virtual one. The importance of this study is to explore how well the high school students performed academically with this change of instructional delivery. So, one can make use of it to infer on student readiness to succeed in college as they make the transition from their high school with the virtual learning that they receive and also infer on the success of future virtual learning at the secondary school level, as well as seek ways for stakeholders to improve teaching and learning in virtual delivery

setting, should the trend continue. In that case, the virtual delivery modality would be an ideal alternative. The background of this study goes hand by hand with teaching and learning theories. Consequently, the theoretical framework of this study focuses on the theory of teaching and learning regardless of the way instructional delivery is conducted.

In more detail, the theoretical framework for this study is a theory on teaching and learning specific to high school students' needs and teachers' designated curriculum objectives. The most commonly used instructional and learning theories in schools are theories of behaviorism, cognitivism, and constructivism. The ultimate goal of implementing these theories in education is student success, and these theories consider many aspects relevant to student success such as classroom management, instructional design, assessments, and effective instructional delivery. According to Duke, Harper, and Johnson (2013), behaviorism focuses on teaching facts and what information is needed for understanding concepts, cognitivism focuses on how the process should be implemented for successful learning, and constructivism focuses on applying real-life situations to what is presented.

A relatively new theory on teaching and learning, called connectivism, incorporates technology in the model that it offers to educators. The use of technology allows teachers to create an interactive and realistic environment with a combination of 3D interactive graphics and web technologies not only in the traditional face-to-face classroom, but also for students in an online setting. To a lower degree of transparency, the theories of behaviorism, cognitivism, and constructivism work well for both face-to-face and virtual instructional delivery modalities. When it comes to virtual teaching and learning, each of these theories contributes to the design of online materials in unique ways (Chittaro and Ranon 2007).

K-12 schools had to shift from the face-to-face teaching and learning instructional delivery modality to a virtual setting for the 2020-2021 school year during the COVID-19 pandemic. Educators took advantage of the existing teaching and learning theories, including the theory of connectivism, and both teachers and students adapted to the change from the face-to-face environment to that of a virtual setting. One study, among many others, similar to this research topic of virtual learning as opposed to traditional classroom face-to-face learning indicated declining achievement and participation in high school mathematics. In the meantime, the same study showed that adaptability to remote learning played a significant role in supporting online student learning experience and achievement (Martin, Collie, Nagy, 2021). A more specific example of reported decrease in learning with virtual instructional delivery during the COVID-19 pandemic in 2020-2021 reveals that the overall statewide student proficiency in terms of academic performance declined by 5 percentage points from the previous school year (Chalkbeat Tennessee: Essential Reporting in Tennessee).

Most literature that was reviewed in relationship to this study presented conclusions about decreased student academic performance during COVID-19 when high school students received virtual instruction. Moreover, some literature presented decreased student academic performance in mathematics. On the one hand, the reviewed literature was about decreased academic performance in general, yet not specific to mathematics. On the other hand, the reviewed literature that was more specific to the academic performance in mathematics presented conclusions on the basis of letter grades earned by students in class and also on grade point average (GPA). Additionally, the reviewed literature did not specifically identify the factors that impacted the student academic performance due to virtual learning. This study, however, is very specific to academic performance of high school students in mathematics receiving their

instruction via virtual delivery modality and the intention of it was to fill in the gap based on the students' standardized test results rather than regular course exams to avoid the conflict of grade inflation. Furthermore, this study aimed to fill in the gap by exploring factors that impacted the academic student performance in mathematics with virtual instruction. The sources that were used for the literature review included reports, articles, and research papers such as:

1. *Learning loss due to school closures during the COVID-19 pandemic*
2. *Covid-19 and Educational Inequality: How School Closures Affect Low- and High-Achieving Students*
3. *COVID-19 and education: The lingering effects of unfinished learning*
4. *COVID-19 and the use of digital technology in mathematics education*
5. *The Effects of Online Mathematics Learning in the Covid-19 Pandemic.*

According to the decrease in learning with virtual instructional delivery, it was hypothesized for this study that the academic performance in mathematics differs between high school students with virtual learning and students with traditional classroom face-to-face learning in meeting the learning objectives of the designated curriculum standards. Additionally, it was also hypothesized for this study that the academic performance in mathematics of high school students receiving virtual instruction correlates with the academic performance of students receiving face-to-face instruction together with other influencing factors such as the demographic categorical classifications breakdown of public schools' student population. This study focused on investigating the extent to which the academic performance in mathematics differs between high school students with virtual learning and students with traditional classroom face-to-face learning.

Statement of the Issue Addressed by the Study

As the country shut down in compliance with "safer at home" orders due to the COVID-19 pandemic, schools shifted to a virtual setting. To evaluate the academic performance of high school students during the shutdown time period, what became interesting as a research topic was addressing this issue as an educator. As a result, this study focused on the following research question: To what extent does the academic performance in mathematics differ between high school students with virtual learning and students with traditional classroom face-to-face learning? The strategy for laying out the groundwork for this study was to align the study with a conceptual framework that includes:

a) The need for virtual learning in high school.

b) Literature review of online instruction and its impact on the academic performance on high school students, especially in mathematics, during the COVID-19 pandemic because this type of instructional delivery was the only alternative method for teaching and learning.

c) Using a sample of public high schools and gather data in order to compare between the academic performance in mathematics of students with virtual learning and students with face-to-face learning.

d) Collecting data on students' standardized test scores prior to the COVID-19 pandemic as well as during the COVID-19 pandemic shutdown, demographics, and socioeconomic status.

e) Using quantitative analysis specific to two-way Analysis of Variance (ANOVA) followed by multi-regression. The two-way ANOVA addresses the part of the research question regarding the existence of significant difference in math performance of high school students receiving virtual instruction and students receiving traditional classroom face-to-face instruction. The multi-regression analysis addresses the main part of the research question regarding the range over which the performance in mathematics of high school students differs between students receiving virtual instruction and students receiving face-to-face instruction.

f) Drawing conclusions on the basis of the results obtained from the data.

Interpretation of the Significance of the Study

Online and virtual learning have been widely used in colleges, and they have shown that the student academic performance does not significantly differ between students who take online or face-to-face courses at the post-secondary level. According to McCarthy (2021), over 36,872 online degrees ranging from an associate degree to a doctoral degree are available at accredited colleges and universities in the USA. Shawnee State University is an example where it offers various online programs, including certificates, undergraduate programs, and graduate programs (Shawnee.edu). This leads to the importance of investigating the academic performance of students with virtual learning in high school for comparison purposes and making inferences about the success of virtual learning in high schools as an alternative to the traditional face-to-face learning.

Historically, remote learning dates all the way back to the 1700s. This method of learning was known as distance learning which was through postal systems available at the time, and it

evolved through the years into radio broadcasting and television programs. Later in the 1990s, distance learning advanced into satellite virtual classrooms, mobile telephones, video conferencing, and the internet. In the present time, distance learning is referred to as online or virtual learning. It is extremely common in the present day for a college student to be or have been enrolled in an online or virtual course. The technical difference between the terms "online" and "virtual" lies in sessions being taught live during a scheduled time in virtual learning (Florida National University, 2019).

Based on the historical perspective on the evolution of distance learning and the success of college and university experiences in using online instruction as well as the rapid advances in technology, it is evident that remote instruction serves the same purpose as the traditional classroom face-to-face instruction. It is also evident that online instruction is just as viable in terms of student academic performance. Accordingly, the significance of this study lies in adding secondary schools as another layer to colleges and universities for online and virtual instruction. With educators' training in the virtual delivery environment, high school students' adaptability to the virtual environment, internet accessibility, computer availability, and advancements in technology, the virtual instructional method could be an effective alternative for secondary schools teaching and learning just like the online instructional delivery practice in colleges and universities.

Overview of Methodology

In order to investigate the extent to which the academic performance in mathematics between high school students with virtual learning and students with traditional classroom face-to-face learning, specific research sub-questions were formulated followed by the methodology that was utilized for this study.

Research sub-questions:

1) Is there a significant difference in the mathematics Tennessee Comprehensive Assessment Program (TCAP) proficiency rates of students between Tennessee public high schools' students with virtual instruction and Tennessee public high schools' students with traditional face-to-face instruction?

2) Is there a significant difference in the academic performance in mathematics between Tennessee public high schools' students residing in an economically disadvantaged county and Tennessee public high schools' students residing in a non-economically disadvantaged county?

3) Is there a significant interaction between the type of instruction and the economic status on the academic performance of Tennessee public high schools' students in mathematics?

4) Which of the 8 independent variables (i-viii) considered in this study are statistically significant in predicting the mathematics TCAP proficiency rates for Tennessee public high schools' students with virtual instruction?

The methodology for this study:

An experimental research design was established for a sample of 143 public high schools in Tennessee where students are required to take standardized tests under the TCAP at the end of each school year. The collected data were specific to standardized tests scores in math courses for the school years 2019-2020 and 2020-2021, where the students received their learning in the traditional classroom face-to-face setting in 2019-2020 while the instructional delivery modality was virtual in 2020-2021 due to the COVID-19 pandemic shutdown. More data were collected, and these data were specific to standardized tests scores in the English subject for the school year 2019-2020, economic status of Tennessee's counties, counties' percentages of people of color,

and the 2019-2020 average ACT math scores pertinent to various classifications of students. The organized collected data were included in Appendices A and B.

The procedures used were first listing each school's percentage of students scoring at the "proficient" level in the math subject in 2019-2020 and 2020-2021 and also in the English subject in 2019-2020 as well as categorizing the schools as "Economically Disadvantaged" and listing the 2019-2020 average ACT math scores. Then, statistical methods were employed, and the software R was used in order to obtain results from the quantitative data for analyzing the results and drawing conclusions. These statistical methods were the two-way ANOVA followed by multi-regression. For the two-way ANOVA, the independent variables were "Economically Disadvantaged" (Yes/No) and "Type of Instruction" (Face-to-Face/Virtual) while the dependent variable was the "Percentage of Students Scoring at the Proficient Level in Math". The two-way ANOVA was used for determining whether the means of the schools' "Percentages of Students Scoring at the Proficient Level in Math" differ between the "Economically Disadvantaged" and the "Economically Non-Disadvantaged" groups and also whether the means of the schools' "Percentages of Students Scoring at the Proficient Level in Math" differ between the "Virtual Instruction" and "Face-to-Face Instruction" groups as well as whether there exists an interaction effect between the type of instruction and the categorization of economic status on the "Percentage of Students Scoring at the Proficient Level in Math".

For multi-regression, the dependent variable was the school's "Percentage of Students at the Proficient Level in Math in 2020-2021" where instruction was virtual. The independent variables were school's "Percentage of Students at the Proficient Level in Math in 2019-2020", "Economically Disadvantaged" (Yes/No), "2019-2020 Average ACT Math Scores Pertinent to Each School for All Students", "2019-2020 Average ACT Math Scores Pertinent to Each School

for Black/Hispanic/Native American Students", "2019-2020 Average ACT Math Scores Pertinent to Each School for Economically Disadvantaged Students", "2019-2020 Average ACT Math Scores Pertinent to Each School for Students with Disabilities", "Percentage of People of Color" in Tennessee counties, and the covariate variable school's "Percentage of Students at the Proficient Level in English in 2019-2020".

The collected data were obtained from credible internet sources such as *Chalkbeat Tennessee: Essential Education Reporting in Tennessee, TN Department of Education: Data Downloads & Requests, TN Transparent Tennessee, and TN County Demographics: Tennessee Arts Commission* where the information is released for the public to use and analyze for research purposes. The website links were provided for acknowledgment, and the names of schools were not revealed for privacy and courtesy considerations. The results obtained from the data were specific to the null hypotheses that were established for testing with ANOVA at significant level $\alpha = 0.05$ and for testing with multi-regression at the designated significance level $\alpha = 0.05$, and correlation coefficient $R = 0$ (See Chapters 3 and 4 for more details).

The sampling of the 143 schools considered in this study was done by some kind of stratified sampling where the strata were taken from massive data sets available and accessible to the public from Chalkbeat Tennessee "Essential Education Reporting in Tennessee" website. The schools used in this study serve as a reasonable representative sample for unbiased conclusions due to the diversity of Tennessee's population and demographics.

The sample size of 143 schools was reasonable for valid results since 8 predictors were used for multi-regression, and a ratio of 15 observations per predictor is adequate to use for multi-regression. According to Sevey (2017), a ratio of 10 observations per predictor is a

minimum requirement for obtaining reliable results in multi-regression analysis. The details of the methodology used for carrying out the research are explained in chapter 3.

Limitations of the Study

Although a solid base was established to carry out this study through statistical procedures, there still remain some limitations in the process. These limitations include the standardized tests being the only measure of academic performance, economically disadvantaged students being measured only by the economic status of the county their school belongs to, using school-by-school percentages of students scoring at the proficient level rather than student-by-student test scores, and high schools from the state of Tennessee only being considered.

Definition of Key Terms

The key terms used in the research question are virtual learning, face-to-face learning, academic performance, and high school.

Virtual learning: Learning that takes place via remote instructional delivery during a scheduled time which is live rather than prerecorded.

Online learning: Learning that takes place via remote instructional delivery, where learning sessions are not live and also students can complete assignments at their own pace and on their own schedule, provided that due dates are specified by their instructors.

Face-to-face learning: Learning that takes place in the traditional classroom setting, with both the students and teacher meeting in person.

Academic performance: Students' achievement measured by the results of their standardized tests rather than their grades.

High school: In the USA, secondary school consists of grades 9 through 12.

Summary

This chapter introduced the background of the study, the issue addressed by the study, the significance of the study, overview of the methodology used to carry out the study, limitations of the study, and definitions of key terms used in the study. Many details will be covered in the following chapters.

Similar studies have been reviewed in order to address the study at hand. These studies addressed academic performance of students with virtual learning. Chapter 2 includes the details of the literature reviews. Hypotheses were set for testing and drawing conclusions, and chapter 3 includes the details of the methodology and the hypotheses used for the study. Chapter 4 presents the results obtained from the collected data regarding the hypothesis. Chapter 5 focuses on conclusions and findings based on the hypotheses test results.

In order to concisely respond to the research question "To what extent does the academic performance in mathematics differ between high school students with virtual learning and students with traditional classroom face-to-face learning?", the strategy was first to test the designated null hypothesis "The academic performance in mathematics does not significantly differ between high school students with virtual learning and students with traditional classroom face-to-face learning" by using two-way ANOVA. Following that, the approach was to test the null hypothesis "The academic performance in mathematics of high school students with virtual learning does not correlate with the academic performance of students with face-to-face learning along with other influencing factors" by using multi-regression, and ultimately to determine and state final conclusions and findings.

Chapter 2 – The Review of Literature

Introduction

The purpose of this study was to explore the extent to which the academic performance in mathematics differs between high school students with virtual learning and students with traditional classroom face-to-face learning. As the country shut down during the COVID-19 pandemic, schools shifted to the modality of virtual instructional delivery. Despite the success of college remote education that dates back to the 1980's, K-12 schools' reports indicate that there was a decrease in the student learning with the virtual mode of instruction.

To address this discrepancy of academic performance between the success of college online instruction and the decreased learning of high school students with virtual learning, a theoretical framework was established in such a way that aligns with educational theories and instructional delivery methods. The theoretical framework allowed for exploring relationships between the academic performance of high school students receiving virtual instruction and students receiving face-to-face instruction.

As an initial step, literature that addressed educational theories and instructional delivery methods was reviewed. Then, the following major themes were established in order to narrow down the research process and focus the scope of the research:

Theme 1: Teaching and learning theories in relation to online instruction

Theme 2: Evolution of distance learning and technology advancement in relation to online learning

Theme 3: The success of the online instructional delivery modality in colleges and universities

Theme 4: Impact of virtual learning on K-12 students during the COVID-19 pandemic

Examples:

a: Learning loss due to school closures during the COVID-19 pandemic

b: COVID-19 and Educational Inequality: How School Closures Affect Low- and High-Achieving Students

c: COVID-19 and education: The lingering effects of unfinished learning

Theme 5: Effect of virtual learning of mathematics on the academic performance of high school students

The literature review themes assisted in finding relevant literature that culminated in responding to the following research sub-questions:

1) Is there a significant difference in the mathematics TCAP proficiency rates of students between Tennessee public high schools' students with virtual instruction and Tennessee public high schools' students with traditional face-to-face instruction?
2) Is there a significant difference in the academic performance in mathematics between Tennessee public high schools' students residing in an economically disadvantaged county and Tennessee public high schools' students residing in a non-economically disadvantaged county?

3) Is there a significant interaction between the type of instruction and the economic status on the academic performance of Tennessee public high schools' students in mathematics?
4) Which of the 8 independent variables (i-viii) considered in this study are statistically significant in predicting the mathematics TCAP proficiency rates for Tennessee public high schools' students with virtual instruction?

The theories considered in this study were behaviorism, cognitivism, constructivism, and connectivism. As mentioned in chapter 1, behaviorism focuses on teaching facts and what information is needed for understanding concepts, cognitivism focuses on how the process should be implemented for successful learning, and constructivism focuses on applying real-life situations to what is presented (Duke, Harper, and Johnson 2013). Connectivism incorporates technology in the model that it offers to educators (Chittaro and Ranon 2007). The following literature pertains to the theoretical framework of this study which is also Theme 1: Teaching and learning theories in relation to online instruction.

Teaching and Learning Theories in Relationship to Online Instruction

Behaviorism Theory: In essence, this theory focuses on teaching facts and what information is needed for understanding concepts. According to Mödritscher (2006), behaviorist learners view the mind as a black box where a response to a stimulus can be observed in a quantitative manner while completely ignoring the effect of thought processes that are occurring in the mind. An implication of this theory is that it relates to online instruction by recommending a structured and deductive approach for designing an online course in order for the basic concepts and skills, as well as facts, to be quickly acquired by the learners. Another implication of this theory is that

online learning can be designed in a modular format where drill and practice are provided and also assessments and feedback are frequently given in a timely manner.

Cognitivism Theory: This theory considers learning as an internal process which consists of memorizing, thinking, and reflecting, as well as aspects of abstraction and motivation. It also involves receiving information, storing the information, and transferring the information to both short-term and long-term memories, by means of different mental processes. The cognitivism theory takes different learning styles and includes various learning strategies because learners perceive, interact with, and respond to learning materials differently (Mödritscher 2006). The implication of this in regard to online learning is that the cognitive theory could apply to virtual learning as long as the instructional design considers breaking down the learning content into smaller pieces and also accounts for different learning styles such as providing visual illustrations, simulation, recorded lectures, slideshows, video demonstrations, and so on.

Constructivism Theory: The gist of this theory emphasizes applying the material learned in class in the real world. In particular, Bruner's constructivism theory is based on the study of cognition. A primary aspect of Bruner's theory is that learners construct new ideas or concepts on the basis of their current and past knowledge. The cognitive components are used to give meaning and organization to current and past experiences and allow for the learner to go further beyond the information provided. The instructor's task is to translate the new learning information into a suitable format for the learner's present state of understanding and organizing in a spiral fashion in order for the learners to continue to build upon what they have previously learned. Additionally, the instructor should direct the students to construct hypotheses, make decisions, and discover learning outcomes such as rules and principles on their own. Technology and web-design aspects are incorporated in this theory to attract and hold the learner's attention. For

example, learners' attention can be drawn by changing brightness of the screen, students' attention can be increased by presenting an element of surprise and suspense, their attention can be focused by using different colors, sounds, and symbols on the screen as well as including pictures, graphics, and illustrations (Patsula 1999). This theory does not specify the way instruction is delivered, and the implication is that the learning could take place regardless of the instructional modality type.

Connectivism Theory: This theory incorporates technology in the model that it offers to educators. According to this theory, learning occurs when learners connect the new knowledge with their prior knowledge. Additionally, knowledge is distributed via an information network, and it could be stored in multiple different digital formats. Furthermore, information continuously changes across the network and consequently the learner's understanding of the information constantly changes (Brieger, Arghode, McLean 2019). The implications of this theory in regard to online learning is that virtual learning is already an integral part of the theory as long as the course design activities and structures align with the practical part of the theory.

In conclusion, the teaching and learning theories implicitly or explicitly include non-traditional ways of learning new information other than the traditional classroom setting. The implications of the teaching and learning theories presented above are in support of virtual instructional delivery as long as the instructional design is aligned with the way learning occurs according to each theory. This literature review reinforces the theoretical framework used in this study.

The next theme that was reviewed pertained to the evolution of distance learning and technology advancement in relation to online learning which was Theme 2.

Evolution of Distance Learning and Technology Advancement in Relation to Online Learning

Remote learning dates back to the 1800s, long before the invention of the internet. In recent years, it evolved to a trend of online offerings via the internet where just about every college in the United States offers classes both face-to-face and online. The following is a historical perspective of distance learning and its evolution to the present time.

Distance learning started as correspondence education where students received instruction and responded by mail. In other words, the whole process of communication between the student and the professor was via mail. Correspondence education grew rapidly and it was offered in many other countries such that a student could be located in Europe taking a class in the United States of America. The postal service was the greatest contributing factor to this type of instructional delivery (Florida National University 2019). The implication here is that correspondence education was a viable alternative to a certain segment of the population where this population was not able to take in-person classes.

The first correspondence school was established in 1888 in Pennsylvania, where it provided training for immigrant coal miners. The purpose of this training was to help these coal miners become eligible for holding state mine inspector or foremen positions. This correspondence school has reached a total of 900,000 students by the year 1906. Afterwards, a correspondence education program was founded in Boston, Massachusetts which was called the Society to Encourage Home Studies. Correspondence education grew with the invention of the radio because it enabled universities to deliver information to students through broadcasting. Pennsylvania State College was the first college that broadcasted courses across radio networks.

Ten years later, with the invention of the television, the University of Iowa employed television as a learning tool. Within five years, more than 15,000 students were enrolled in college courses for credit where these courses were delivered through the television. Although it was very difficult to earn a college degree though television, some students were able to graduate with a bachelor's degree by taking televised courses (Florida National University 2019). The implication of this is that remote education was in more demand for people who could learn with audio and video tools while they cannot be in the physical classroom due to their personal obligations.

As technology continued to advance during the 1980s, the telecommunications systems allowed students to interact with one another and with their professors. The teaching and learning processes were active rather than passive because of the communication that took place between the students and the professor, despite the courses were delivered via television. National Technological University offered the first accredited virtual university in 1984 with the support of the companies IBM, Motorola, and HP (Florida National University 2019). The implication here is that the distance education alternative was in more demand due to the availability in communication tools between the learners and the instructors and also due to the ability of more interaction while learners were not required to be in the classroom.

In the late 1980s, the invention of the personal computer along with the internet played a big role in advancing distance education from television delivery to online delivery. The University of Phoenix was the first educational institution to offer bachelors and master's degrees fully online in 1989. In the late 1990s, about 100,000 students were interested in taking online courses and universities had difficulties at that time meeting such a demand. During the 1990s, technology was advancing relatively rather quickly where distance learning was offered

through different media such as satellite virtual classrooms, mobile telephones, video conferencing, and the internet. (Florida National University 2019). This implies the removal of more barriers made instructional delivery more accessible to learners and ultimately the advancement of technology opened the doors for more learners to receive a college degree without being bound to attend classes in person.

With the exponential advancement of technology in the 21st century, approximately 89% of four-year public colleges in the United States and about 60% of private educational institutions offered online courses by 2006. Nowadays, distance learning is referred to as online education and every student should be familiar with online courses, especially given that all educational institutions converted to virtual or online delivery instruction during the COVID-19 pandemic (Florida National University 2019). This implies that the alternative of online education was effective for a wide sector of the population.

Currently, online and virtual learning have been widely used in post-secondary educational institutions. These institutions have shown that the student academic performance does not significantly differ between students who take online or face-to-face courses at the post-secondary level. Over 36,872 online degrees ranging from an associate degree to a doctoral degree are available at accredited colleges and universities in the United States of America (McCarthy 2021). Shawnee State University is an example where it offers various online programs, including certificates, undergraduate programs, and graduate programs (Shawnee.edu). The implication here is that the trend of online education is becoming the right direction for future education beside the face-to-face education.

In a nutshell, the literature review of the evolution of distance learning is significant to this study because the purpose of this study was to explore academic performance of high school students with the virtual instructional delivery method. The next theme that was reviewed pertained to the success of online instructional delivery modality in colleges and universities which was Theme 3. The purpose of the review of this theme was to look into the implications and to show the practicality aspect of the virtual instructional delivery type that can be recommended for high school students who wish to go in that direction of virtual schools.

The Success of the Online Instructional Delivery Modality in Colleges and Universities

According to Jahng, Krug, and Zhang (2007), the online instructional method is just as effective as the traditional face-to-face instructional method in terms of academic performance and student satisfaction. This implies that the success of online education is similar to that of face-to-face education. The following literature supports the success of the online instructional delivery modality in colleges and universities.

Post-secondary student learning outcomes in hybrid (more than 50% online) and 100% online courses were found to be equal or better than the student learning outcomes in the physical classroom courses. The online education offers well-prepared and motivated students the benefit of convenience and flexibility in pursuing their degrees by being able to take classes at times that best work for them according to their personal commitments and schedule (Jaggars and Bailey 2010).

According to Harrell II (2008), many colleges and universities have offered online courses, online degrees, and certificate programs by taking advantage of the internet utility.

Additionally, online instruction has been regarded as an effective tool for instructional delivery. Furthermore, student retention in online courses can be increased when educational institutions use student readiness instruments to identify students' strengths and weaknesses for proper advising in regard to their potential success in online courses. Student orientation is also important in exposing students to experiences related to online courses so students can determine their potential success if they enroll in these types of courses. Moreover, providing adequate academic and technical support resources for online students can result in increased student success.

According to Hamann, Glazeir, Wilson, and Pollock (2020), nearly all students have taken at least one course online and many students have earned college degrees online. It is expected that more students are inclined to take more online courses especially after the COVID-19 pandemic where there was a complete shift to online instruction in the USA. Accordingly, educators and policy makers should plan strategies that address the needs of online learners to ensure higher success rates, retention rates, completion rates, and graduation rates.

In conclusion, the review of the above literature for Theme 3 demonstrates the effectiveness and success of post-secondary online courses as long as the learner is well-prepared, motivated, responsible, and interested given that the instructional design is suitable, academic resources are available, and technical support is accessible for the learners. The next theme that was reviewed pertained to the impact of virtual learning on K-12 students during the COVID-19 pandemic which was Theme 4. The purpose of the review of this theme was to examine learning loss, performance and achievement gaps, and the potential of student success in the virtual setting worldwide.

Impact of Virtual Learning on K-12 Students During the COVID-19 Pandemic

According to Simpson (2020), many challenges faced K-12 students and parents related to learning at home during the COVID-19 pandemic. These challenges include access to the necessary technology such as internet, microphone, webcam, and training on how to use the online classroom. Additionally, home was not the best learning environment for many students since the rest of the family were present, doing their own work and house chores. Also, there was typically not enough space in the house conducive to effective learning. In the meantime, remote learning during the COVID-19 pandemic gave K-12 educators the opportunity to improve online instruction and reconsider the course instructional design to better meet the needs of students and families. The following literature considers the impact of virtual learning on K-12 students during the COVID-19 pandemic in terms of drawbacks and successes.

According to Tanveer, Bhaumik, Hassan, and Haq (2020), most parents were not educated enough in the requisite technology to help their children with their schoolwork and had a hard time in dealing with internet issues which affected student learning. Specifically, speed and connectivity were a major problem for the use of the internet with regard to the virtual learning. Accordingly, many students in their senior year (12^{th} grade) had difficulty with the virtual delivery method in meeting due dates for their assignments, projects, and assessments. That put more pressure and stress on students and negatively impacted their academic performance.

According to Rasmitadila, Aliyyah, Rachmadtullah, Samsudin, Syaodih, Nurtanto, and Tambunan (2020), online learning in Indonesia during the COVID-19 pandemic was successful due to the alignment of technology with the national humanist curriculum, support, and collaboration from the government, schools, teachers, parents, and the community. More

specifically, online learning was successful because necessary changes were made for instructional strategies, implementation of technology, technical support, and motivation to all concerned parties. Additionally, online learning was successful by making changes in the national curricula and increasing the flexibility of due dates as well as the collaboration of all stakeholders such as the government, teachers, parents, and schools.

According to YAN, Whitelock-Wainwright, Guan, Wen, *Gašević*, and Chen (2021), student success in K-12 online education in China was significantly lower than face-to-face education. Additionally, students experienced many difficulties and faced challenges in the virtual setting. Such difficulties and challenges included technical support, internet problems, learning platforms customized for smart phones, and lack of learning resources.

According to Huck and Zhang (2021), students, parents, and educators in the United States faced many challenges. Those challenges included limited access to infrastructure for online learning, insufficient digital literacy skills for stakeholders, and in some cases inadequate teacher remote instruction delivery competence. This created some achievement gaps and therefore, it was essential for educators to get the support for instructional technology training and meeting the academic needs of the students.

According to Aldrich and Wilburn (2021), overall student proficiency in the State of Tennessee declined by 5 percentage points during the COVID-19 pandemic. According to TN Department of Education (2021), the results of the 2020-2021 spring Tennessee Comprehensive Assessment Program (TCAP) tests showed decreases in students' proficiency. In particular, the most negative impacts pertained to economically disadvantaged students, English learners, and students of color. The overall English Language Arts proficiency decreased by 5 percentage points from 2019. Students from Hispanic and Asian races experienced a 12 to 13 percentage

point decrease in Math from 2019. Overall, proficiency rates in science decreased by one-third for all Tennessee public school students. Additionally, proficiency rates in social studies declined by 4 percentage points in Tennessee middle schools, though increased by 4 percentage points in high school.

According to Wrenn (2015), public high school students in North Carolina performed academically equally in English using both virtual and face-to-face instructional delivery methods. Moreover, there was no significant difference between the academic performance of males and females. Caucasian performance was higher with the online instructional delivery method while Hispanic student achievement was higher in the face-to-face classroom setting. On top of that, Wrenn (2015) concluded that there was no significant difference in overall academic performance between students receiving online instruction and students with traditional face-to-face classroom instruction.

In conclusion, the literature review for Theme 4 indicated both learning losses and successes. Most of the learning losses were due to challenges with technology, limited technical support, and a nontraditional learning environment (home environment). Some learning successes were due to government, parents, teachers, and policy makers' support. The implications of the reviewed literature for Theme 4 pointed to opportunities with online learning as an alternative instructional delivery method for high school students as long as necessary support and training are provided. Although there are some disadvantages to online learning, there are many advantages to it for high school students who think that learning online at home is the right option for them. Some disadvantages include fewer social opportunities, student dependence on himself/herself more than on the teacher, self-motivation, willingness to lose participation in high school after school activities, and lack of physical resources such as

calculators, books, libraries, gym, and so on. Some of the advantages include the chance for students to work at their own pace, more flexible schedules, fewer social pressures, and avoiding negative environments. The next theme that was reviewed pertained to the effect of virtual learning of mathematics on the academic performance of high school students which was Theme 5.

Effect of Virtual Learning of Mathematics on the Academic Performance of High School Students

The following literature considered the impact of virtual learning of mathematics on high school students' attitudes perception and academic performance.

According to Almarashdi and Jarrah (2021), high school students were challenged in mathematics courses during the COVID-19 pandemic while receiving virtual instruction and students indicated negative perceptions such as missing interaction with teachers and peers. Additionally, students indicated preference of face-to-face education in mathematics although they noted advantages of virtual education such as flexibility and independence education. The students preferred face-to-face instruction over virtual because they faced many challenges with virtual learning such as technical difficulties, long periods of time spent in front of a computer screen, difficulty of understanding lessons on their own, and the absence of the interaction with their teachers and friends at school.

According to Spitzer and Musslick (2021), German high school students' performance in mathematics increased during the COVID-19 pandemic school shutdowns with virtual instruction as compared to their performance in the previous year with traditional face-to-face instruction. Additionally, the low-achieving students showed greater performance improvement

in mathematics than the high-achieving students. This suggests that the gap in performance between the low-achievers and high-achievers was narrowed down in mathematics with the virtual type of instruction. Furthermore, Spitzer and Musslick (2021) concluded that online learning settings might be effective in avoiding educational losses related to present and future shutdowns of school

According to Cavanaugh (2013), high school students had challenges with virtual learning of mathematics. The challenges were specific to formulas, diagrams, problem solving, abstract concepts, and symbolic representations. The implication of this is that high school students had difficulty learning many mathematical concepts without the presence of, nor interaction with, the teacher in the traditional face-to-face setting.

According to Cavanaugh, Gillian, Kromrey, Hess, Blomeyer (2004), high school mathematics has proven to be difficult to teach online in order for the students to understand the concepts as they would when it is taught face-to-face. Additionally, the high school students' performance in mathematics were significantly lower with virtual learning than their scores with face-to-face learning. The implication here is that the academic performance of high school students in mathematics with virtual learning should be examined separately from other courses when evaluating the overall academic performance of students with virtual learning since mathematics is a highly technical course at this level as compared with other high school courses.

In conclusion, students faced the same technical challenges in learning mathematics with virtual instruction as in learning other subjects. However, they had a more difficult time in attaining the same quality of performance with virtual learning due to the complexity of

understanding highly technical concepts in the absence of the physical presence of a teacher. With a well-designed high school mathematics course specifically tailored to online delivery along with the use of best practice for online teaching and student self-motivation as well as student preparedness, the online delivery method for mathematics could be a viable option for students who think it is the right choice for them.

Summary

The review of literature helped in seeking relevant information and compiling very important theories and findings concerning this study. The theories addressed teaching and learning aspects as well as instructional delivery methods, the evolution of distance learning and technology advancement in relation to online learning, the success of online instructional delivery modality in colleges and universities, the impact of virtual learning on K-12 students during the COVID-19 pandemic, and the effect of virtual learning of mathematics on the academic performance of high school students. The literature review paved the road for planning and preparing a road map for the research study and ultimately to execute the plan. This chapter was the key factor in every step taken to carry out the investigation for the research study.

The literature review was significant in supporting and reinforcing the theoretical framework for the study, developing and establishing reliable methods for sampling and data collection, choosing an appropriate statistical design, utilizing statistical methods to present and analyze data results, and comparing the results with findings of similar studies. The details of these issues have been discussed in chapters 4 and 5.

Chapter 3 – Explaining the Methodology

Introduction

This chapter explains the methods used in carrying out the study, giving special emphasis to the steps taken for the analysis of data. It states the type and general perspective of the study, describes the context of the study, identifies the participants, describes the process used to collect data, explains the design and the procedures used to carry out the design, and explains the strategies used to analyze data.

The General Perspective

The two-way ANOVA and multi-regression analyses were reported for addressing the research question: To what extent does academic performance in mathematics differ between high school students with virtual learning and students with traditional classroom face-to-face learning? Quantitative data were collected and analyzed along with a qualitative follow-up to interpret the data that reflected the academic performance of high school students in mathematics during the COVID-19 pandemic shutdown, where students received virtual instruction. The academic performance of high school students in mathematics was measured by using standardized tests that aligned with the learning objectives of designated curriculum standards. The reported academic performance in mathematics of high school students receiving virtual instruction was compared with the academic performance in mathematics of high school students who received traditional classroom face-to-face instruction in previous years. The intent was to determine whether or not there was a gap in the academic performance of students across two types of instructional delivery modalities, so that educators could seek ways to improve the instructional delivery methods to better fit the students' needs.

The two-way ANOVA analysis technique was used to compare the academic performance of the high school student population in mathematics across two types of instruction and two categorizations of economic status based on the data collected from the sample. In more detail, two-way ANOVA is an extension of the one-way ANOVA. One-way ANOVA is used to test if there is a difference between three or more means. In conducting a study that involves two-way ANOVA, the researcher can test the effects of two independent variables on one dependent variable and also the interaction effect of the two variables (Bluman 2019). Although the two-way ANOVA provided information about differences in academic performance in mathematics between high school students with virtual learning and students with traditional classroom face-to-face learning, it did not give information that could be used to draw conclusions about relationships. The independent variables for this study were the "Type of Instruction" and the categorization of the "Economic Status of the County the School is Located in", while the dependent variable was the school's "Percentage of Students Scoring at the Proficient Level in a Standardized Test".

Regarding multi-regression, it is a relationship between a dependent variable and two or more independent variables. In general, linear regression equations are represented as: $\hat{y} = b_0 + b_1x_1 + b_2x_2 + \ldots + b_nx_n$ where $\hat{y}$ is the dependent variable, x_1 through x_n are the independent variables, n is the number of independent variables, and b_0 is the intercept. The dependent variable was the schools' "Percentage of Students at the Proficient Level in Math in 2020-2021" where instruction was virtual. This is the proficiency rate of students on the TCAP math test in each of Tennessee's public high schools that were considered in the sample in 2020-2021 where the students were receiving virtual instruction. The independent variables for multi-regression were "Percentage of Students at the Proficient Level in Math in 2019-2020", "Economically

Disadvantaged Counties in Tennessee", "2019-2020 Average ACT Math Scores Pertinent to Each School for All Students", "2019-2020 Average ACT Math Scores Pertinent to Each School for Black/Hispanic/Native American Students", "2019-2020 Average ACT Math Scores Pertinent to Each School for Economically Disadvantaged Students", "2019-2020 Average ACT Math Scores Pertinent to Each School for Students with Disabilities", "Percentage of People of Color in Tennessee Counties", and the covariate variable schools' "Percentage of Students at the Proficient Level in English in 2019-2020".

The following is a brief explanation of what each independent variable indicates.

i) "Percentage of Students at the Proficient Level in Math in 2019-2020" indicates the proficiency rate of students on the TCAP math test in each of Tennessee's public high schools that were considered in the sample in 2019-2020 where the students were receiving face-to-face instruction.

ii) "Economically Disadvantaged Counties in Tennessee" indicates whether the school is located in an economically disadvantaged county or economically non-disadvantaged county.

iii) "2019-2020 Average ACT Math Scores Pertinent to Each School for All Students" indicates the average ACT math scores in each of Tennessee's public high schools that were considered in the sample in 2019-2020 where the students were receiving face-to-face instruction.

iv) "2019-2020 Average ACT Math Scores Pertinent to Each School for Black/Hispanic/Native American Students" indicates the average ACT math scores of Black/Hispanic/Native American students in each of Tennessee's public high schools

that were considered in the sample in 2019-2020 where the students were receiving face-to-face instruction.

v) "2019-2020 Average ACT Math Scores Pertinent to Each School for Economically Disadvantaged Students" indicates the average ACT math scores of economically disadvantaged students in each of Tennessee's public high schools that were considered in the sample in 2019-2020 where the students were receiving face-to-face instruction.

vi) "2019-2020 Average ACT Math Scores Pertinent to Each School for Students with Disabilities" indicates the average ACT math scores of students with disabilities in each of Tennessee's public high schools that were considered in the sample in 2019-2020 where the students were receiving face-to-face instruction.

vii) "Percentage of People of Color in Tennessee Counties" reflects the assumed percentage of people of color in each school located in the respective counties.

viii) The covariate variable schools' "Percentage of Students at the Proficient Level in English in 2019-2020" indicates the proficiency rate of students on the TCAP English test in each of Tennessee's public high schools that were considered in the sample in 2019-2020 where the students were receiving face-to-face instruction.

The assumptions for two-way ANOVA accounted for normality of the populations from which the samples were obtained, independence of the samples, and equality of the variances of the populations from which the samples were selected. The assumptions for multi-regression requires that the regression model can be expressed in a linear equation (linearty assumption), the independent variables are not correlated (nonmulticollinearty assumption), the variance of

errors is constant (homoscedasticity), the errors are independent (independence assumption), and that the errors are normally distributed (normality assumption).

The Research Context

The study was conducted during the spring semester of 2022, and it considered 143 public high schools from the state of Tennessee. The schools were chosen from a spectrum of economically disadvantaged counties and a range of economically non-disadvantaged counties. Schools typically serve the student needs and they reflect a high degree of student population diversity. The school districts provide reasonable accommodations for students with disabilities, and they reflect the ethnic and racial, as well as gender and socioeconomic status, composition of the counties they are located in. At the end of each school year, the students take standardized tests in nearly all subjects under the Tennessee Comprehensive Assessment Program (TCAP) and these tests are aligned with the state's designated curriculum standards. According to TN Department of Education, TCAP has been the state's testing program since 1988 and it includes TN Ready assessments in math, English, language arts, social studies, and science, as well as alternative assessments. Thus, the results of the sample that was used for this study could be used to make inferences and generalize about other public schools in Tennessee and across the nation.

The Research Participants

The direct research participants were public high schools from Tennessee, and the indirect research participants were the students attending these schools. The schools reflect diverse demographic composition of their students and the counties they are located in. A total of 143 schools participated in this study. From these participants, 36 schools were located in 20 of the 39 different economically disadvantaged counties and 107 schools were located in 38 of the 56

different economically non-disadvantaged counties. More precisely, at least one of the 36 economically disadvantaged schools was located in each of the 20 different economically disadvantaged counties and at least one of the 107 economically non-disadvantaged schools was located in each of the 38 different economically non-disadvantaged counties.

The counties' economic status designations are identified through a composite measure of each county's 3-year average unemployment rate, per capita market income, and poverty rate (Transparent Tennessee). The 143 participating schools were chosen for this study because they had all the necessary information for the multi-regression analysis and, consequently, for the two-way ANOVA analysis, while the vast majority or nearly all of the remaining public high schools in Tennessee had at least one critical piece of missing information.

The Process Used in Data Collection

A methodological framework was established in order to investigate the research question. This framework was based on theory, research, and development in order to provide reliable and valid data and measures. According to the National Academics Press: Testing, Teaching and Learning: A Guide for States and School Districts (1999), a necessary condition of the theory of action of standards-based reform is the alignment of tests with the state's curriculum standards and learning objectives because the alignment ensures that the tests match the learning goals embedded in the standards and also enables the public to determine student progress toward the standards. According to Abaidoo (2018), common contributing factors that impact the student academic performance include self-motivation, attitude toward learning and interest in the subject, classroom environment, classroom management and teacher presentation, parents' education and socio-economic status, gender, ethnicity and race, and availability of teaching and learning resources.

The results of a pilot conducted for this study showed a correlation between academic performance in math and academic performance in English. It also showed that academic performance in math correlates with previous academic performance in math.

The Design and Procedures Used to Carry Out the Design

In order to investigate the research question regarding the extent to which the academic performance in mathematics differs between high school students with virtual learning and students with traditional classroom face-to-face learning, specific research sub-questions were formulated followed by the design and procedures used to carry out the design that was utilized for this study.

Below are the research sub-questions:

1) Is there a significant difference in the mathematics TCAP proficiency rates of students between Tennessee public high schools' students with virtual instruction and Tennessee public high schools' students with traditional face-to-face instruction?
2) Is there a significant difference in the academic performance in mathematics between Tennessee public high schools' students residing in an economically disadvantaged county and Tennessee public high schools' students residing in a non-economically disadvantaged county?
3) Is there a significant interaction between the type of instruction and the economic status on the academic performance of Tennessee public high schools' students in mathematics?

4) Which of the 8 independent variables (i-viii) considered in this study are statistically significant in predicting the mathematics TCAP proficiency rates for Tennessee public high schools' students with virtual instruction?

Upon approval of the Institutional Review Board (IRB) research proposal form for this study, an experimental research design was established for a sample of 143 public high schools in Tennessee where students are required to take standardized tests under the Tennessee Comprehensive Assessment Program (TCAP) at the end of each school year. The collected data were specific to standardized tests scores in math courses for the school years 2019-2020 and 2020-2021, where the students received their learning in the traditional classroom face-to-face setting in 2019-2020 while the instructional delivery modality was virtual in 2020-2021 due to the COVID-19 pandemic shutdown.

The collected data were also specific to standardized tests scores in the English subject for the school year 2019-2020 as well as on the economic status of Tennessee's counties and also on the counties' percentages of people of color. The idea behind including the English subject as a predictor was to use it as a covariate because there is a positive correlation between English language arts skills and math achievement according to many studies. The "English" variable was used as a covariate since it was not of an interest by itself to the study of academic performance in mathematics, but it could help since many studies showed that English and mathematics are positively correlated. According to Rambely, Ahmad, Majid, Jaaman (2013), good English skills are needed for understanding mathematics and better achievement while low proficiency in English results in lower achievement in mathematics.

More data were collected, and these data were specific to the 2019-2020 average ACT math scores pertinent to each school for all students, Black/Hispanic/ Native American students,

economically disadvantaged students, and students with disabilities. The procedures used were first listing each schools' percentage of students scoring at the "proficient" level in the math subject in 2019-2020 and 2020-2021 and in the English subject in 2019-2020 as well as categorizing the schools as "Economically Disadvantaged" depending on whether or not they are located in economically disadvantaged counties. The 2019-2020 average ACT math scores pertinent to each school for the four mentioned categories above were also listed.

The collected data were obtained from credible internet sources such as *Chalkbeat Tennessee: Essential Education Reporting in Tennessee, TN Department of Education: Data Downloads & Requests, TN Transparent Tennessee, and TN County Demographics: Tennessee Arts Commission* where the information is released for the public to use and analyze for research purposes. The website links were provided for acknowledgment, and the names of schools were not revealed for privacy and courtesy considerations. Instead, the schools were listed as "school #1 and county #x_1", "school #2 and county #x_2", "school #3 and county #x_3", and so on.

The programming language and the software for statistical computing, called R, was used to analyze the results obtained from the data (R Core Team 2020). The data were first organized in Excel and then exported into the software R. The results obtained from the data were specific to the null hypotheses that were established for testing with ANOVA at significant level $\alpha = 0.05$ and for testing with multi-regression at the designated significance level $\alpha = 0.05$, and correlation coefficient $R = 0$.

The number of public high schools involved in this study was 143 schools were selected from 58 (out of 95) Tennessee counties. The sampling of these schools was done by stratified sampling where the strata were taken from massive data sets available and accessible to the public from Chalkbeat Tennessee "Essential Education Reporting in Tennessee" website, and the

data were gathered the hard way by sieving and digging through the reported information in order to find, compile, and organize the necessary data used for this study. The schools used in this study serve as a reasonable representative sample statewide for unbiased conclusions because of the following facts about Tennessee's schools demographics for the school year 2020-2021 (TN Department of Education):

TN Schools Demographics	Percentage
Black/Hispanic/Native American	37.1%
Multi Race	16.3%
African American	24.3%
Asian	2.6%
Hispanic	12.3%
Native American/Other	< 1%
White	60.1%
Economically Disadvantaged	33.5%
Students with Disabilities	13.5%
Limited English Proficiency	7.8%
Homeless	1.1%
Female	48.8%
Male	51.2%

Additionally, the stratification technique of sampling added more reliability for unbiased conclusions. Sampling by stratification was conducted in such a way that allows for collecting necessary data that would align with the designated predictors used in this study with the

intention of leaving no spots empty upon entry of the data. Due to that restriction, the 143 schools that comprised the sample were picked from 20 of 39 different economically disadvantaged counties and 38 of 56 different economically non-disadvantaged counties. It turned out that the sample of 143 was a combination of a sub-sample of 36 public high schools located in economically disadvantaged counties and another sub-sample of 107 public high schools located in economically non-disadvantaged counties. The sample size was adequate to use for two-way ANOVA and obtain valid results since it is greater than 30 (Bluman 2019). Eight predictors were used for multi-regression and a ratio of 15 observations per predictor is adequate to use for multi-regression. According to Sevey (2017), a ratio of 10 observations per predictor is the minimum requirement for obtaining reliable results in multi-regression analysis.

Summary

The chapter presented the general perspective of this study, the research context, the research participants, the process used in data collection, the design and procedures used to carry out the design, and the data analysis strategies. With this methodology, the groundwork was laid out for the results and data analysis. The details and the analysis of the results have been provided in Chapter 4, and they have been presented in the order of the research sub-questions 1, 2, 3, and 4 that were listed earlier on in the chapter.

Chapter 4 – Presenting the Results

Introduction

The study reported here investigated in detail the extent to which the academic performance in mathematics differs between high school students with virtual learning and students with traditional classroom face-to-face learning. The chapter is organized according to the following two primary components of the research question:

I) Is there a significant difference in the academic performance in mathematics between high school students with virtual learning and students with face-to-face learning?

II) How does the academic performance in mathematics interrelate between high school students who receive virtual instruction and students who receive face-to-face instruction?

More specifically, the organization of the chapter is consistent with the following research sub-questions along with the hypotheses as they align with components I and II above:

1) Is there a significant difference in the mathematics TCAP proficiency rates of students between Tennessee public high schools' students with virtual instruction and Tennessee public high schools' students with traditional face-to-face instruction?

2) Is there a significant difference in the academic performance in mathematics between Tennessee public high schools' students residing in an economically disadvantaged county and Tennessee public high schools' students residing in a non-economically disadvantaged county?

3) Is there a significant interaction between the type of instruction and the economic status on the academic performance of Tennessee public high schools' students in mathematics?
4) Which of the 8 independent variables considered in this study are statistically significant in predicting the mathematics TCAP proficiency rates for Tennessee public high schools' students with virtual instruction?

The criteria for rejecting the null hypotheses were set at significance 0.05. More precisely: If $p < .05$, reject H_o and conclude that there is a significant difference. If $p > .05$, do not reject H_o and conclude that there is no significant difference.

Research sub-questions 1, 2, and 3 associate with Component I above, and they are directly linked with the two-way ANOVA analysis that was employed for generating results. Sub-question 4 pertains to Component II above, and it is directly linked with the multi-regression analysis that was incorporated for obtaining results.

Data are presented in tables that have been developed and displayed according to the guidelines offered by the APA Publication Manual. The development of the tables has been performed by using the software application, R.

Two-Way ANOVA Analysis Results

The two-way ANOVA was used to respond to Component I and sub-questions 1, 2 and 3 mentioned earlier. In Table 1, the types of instruction were face-to-face (2019-2020) and virtual (2020-2021). Socioeconomic status refers to economically disadvantaged counties and economically non-disadvantaged counties for the school districts considered in the study.

Table 1 *Two-Way ANOVA: Type of Instruction and Socioeconomic Status*

Df	Sum Sq	Mean Sq	F Value	Pr(>F)	
1	6593	6593	46.071	6.72E-11***	
1	485	485	3.387	0.0667	
1	123	123	0.857	0.3553	
282	40357	143			
0 '***'	0.001 '**'	0.01 '*'	0.05 '.'	0.1 ' '	1

The data in Table 1 pointed to the following specific results regarding research sub-questions 1, 2, and 3:

1) A significant difference exists between the means of "Percentage of Students Scoring at the Proficient Level in TCAP Math Tests" across students using virtual instruction and students using face-to-face instruction. The difference is considered significant since a p-value < 0.001, which is less than the designated significance level 0.05, was reported with the "Virtual and Face-to-Face" type of instruction. Since the p-value is less than the significance level, the decision regarding the null hypothesis that states "no significant difference" is to reject it. Accordingly, the conclusion was that the data provided sufficient evidence to support the existence of a significant difference between the means.
2) No significant difference exists between the means of "Percentages of Students Scoring at the Proficient Level in TCAP Math Tests" across students attending schools located in economically disadvantaged counties and students attending schools located in economically non-disadvantaged counties. The difference is not considered significant since a p-value = 0.0667, which is greater than the designated significance level 0.05, was reported with the "Economically Disadvantaged County Yes and No". Since the p-value is greater than the significance level, the decision regarding the null hypothesis that states

"no significant difference" is to not reject it. Accordingly, the conclusion was that the data provided sufficient evidence to not support the existence of a significant difference between the means.

3) No significant interaction effect on the "Percentages of Students Scoring of the Proficient Level in TCAP Math Test" exists between the type of instruction and the county socioeconomic status. The interaction is not considered significant since a p-value of 0.3553, which is greater than the designated significance level .05, was reported with "Virtual and Face-to-Face type of instruction" × "Economically Disadvantaged County Yes and No". The decision regarding the null hypothesis that states "no significant interaction" is not to reject it. Accordingly, the conclusion was that the data provided sufficient evidence to not support the existence of a significant interaction effect on the "Percentages of Students Scoring at the Proficient Level in TCAP Math Test" between the types of instruction and the county socioeconomic status.

Table 2 *Two-Way ANOVA: Type of Instruction and Socioeconomic Status without Interaction (with posthoc analysis)*

	Df	Sum Sq	Mean Sq	F Value	Pr(>F)	
Instruction	1	6593	6593	46.094	6.61E-11×**	
Economically.Disadvantaged	1	485	485	3.389	0.0667	
Residuals	283	40480	143			

Signif. codes:	0 '***'	0.001 '**'	0.01 '*'	0.05 '.'	0.1 ' '	1

Table 2 continued

Tukey multiple comparisons of means				
95% family-wise confidence level				
Fit: aov(formula = Ppercentage.of.Students.TCAP.MATH ~ Instruction + Economically.Disadvandtaged)				
$Instruction				
	diff	lwr	upr	p adj
V-F	-9.602797	-12.38688	-6.818711	0
$Economically Disadvantaged				
	diff	lwr	upr	p adj
Yes-No	-2.999688	-6.207032	0.2076553	0.0666768

Table 2 indicated that the only significant difference was between the mean TCAP math school's proficiency rate of students with virtual instructional type and the mean TCAP math school's proficiency rate of students with face-to-face instruction since the p-value is less than the designated 0.05 significance level. This difference was approximately 9.6 percentage points lower for the virtual type of instruction. Table 2 showed a mean difference of -9.602797 along with confidence interval (-12.38688, -6.818711). Since -9.602797 is the center of the confidence interval, the difference between each endpoint of the confidence interval and the mean difference -9.602797 is about 2.8. Accordingly, the difference between the means of TCAP math school's proficiency rate of students with virtual and face-to-face instruction was about 9.6 ± 2.8 percentage points with mean TCAP math proficiency rate being lower for virtual instruction than that with face-to-face instructional delivery type.

Examining the two-way ANOVA assumptions showed that the independence of variables assumption was met because the types of instruction are distinct from the socioeconomic status

and have no effect on each other. Testing for normality and homogeneity of variances assumptions by using Shapiro-Wilk test and Levene's Test showed violations for both assumptions since the p-values were less than the designated 0.05 value (Tables 3 and 4). This indicates that two-way ANOVA analysis may be tolerated to obtain more valid results.

Table 3 *Shapiro-Wilk Normality Test*

Shapiro-Wilk normality test	
data: res	
W = 0.94628,	p-value = 1.014e-08

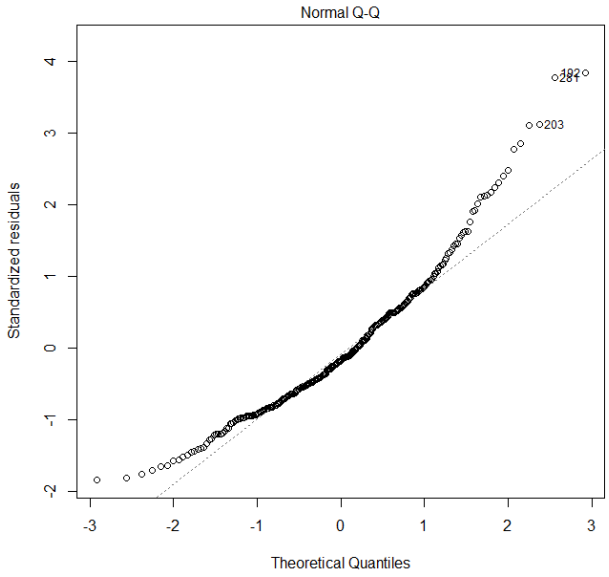
Table 4 *Levene's Test for Homogeneity of Variance*

Levene's Test for Homogeneity of Variance (center = mean)						
	Df	F value	Pr(>F)			
Group	3	6.0368	0.000536***			
	282					

Signif. codes:	0 '***'	0.001 '**'	0.01 '*'	0.05 '.'	0.1 ' '	1

However, plot 1 showed an approximately normal distribution (Normal Q-Q) due to the majority of the points fitting with a straight line. Plot 2 showed no evident relationships between the residuals and fitted values (Residuals vs Fitted) so, the homogeneity of variances assumption could be considered nearly met. Plots 1 and 2 showed that some outliers were contributing to the violation of Shapiro-Wilk and Levene's tests.

Plot 1 *Normal Q-Q*



Plot 2 *Residuals vs Fitted*

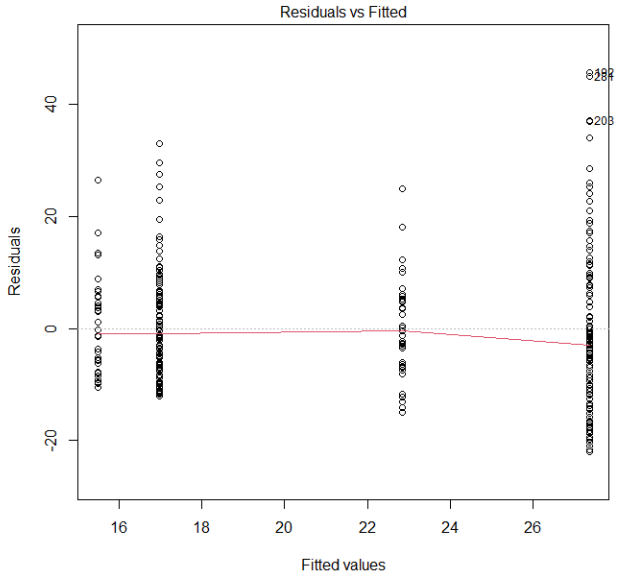


Table 5 showed an additional result regarding the significant difference that existed between the means of the TCAP math proficiency rates concerning face-to-face and virtual types of instruction.

Table 5 *Means and Standard Errors of TCAP Math Proficiency Rates*

	Mean	Standard Error
TCAP Math Proficiency Rate (Face-to-Face)	26.2126	1.167565
TCAP Math Proficiency Rate (Virtual)	16.6098	0.8088001

The results of the descriptive statistics in Table 5 showed a mean of 26.2126 along with a standard error of 1.167565 for the "Percentage of Students Scoring at the Proficient Level in TCAP Math Test" when the face-to-face instruction type was used and also a mean of 16.6098 along with a standard error of 0.8088001 for the "Percentage of Students Scoring at the Proficient Level in TCAP Math Test" when the virtual instruction type was used. The difference

in the means was 9.6028 percentage points, and it was a significant difference from what was previously reported. The number of standard errors from the mean difference was calculated as follows: $1.96 \times \sqrt{(1.167565^2 + 0.8088001^2)} = 2.7839$ where 1.96 is the critical value of t (student's t) at significance $\alpha = 0.05$ and degrees of freedom, df = 142 (which is n – 1, where n is the sample size). Consequently, the difference between the means was 9.6028 ± 2.7839 percentage points and it was significant. This result concurs with the result obtained in Table 2 and provides the following additional finding: The ratio of the mean 16.6098 to the mean 26.2126 results in $16.6098/26.2126 \approx 63.4\%$, which indicates that the TCAP math proficiency rate of students with virtual instructions was approximately 63.4% of the TCAP proficiency rate of the students with face-to-face instruction. Roughly, the ratio of students scoring at the proficient level with virtual instructions to students with face-to-face instructions was 2 to 3.

According to the Tennessee Department of Education website, the statewide overall student proficiency in math declined by 12 percentage points with virtual instruction for a total of over 1,800 public schools, from grade 3 through grade 12. This indicates that the difference in the means obtained from Table 5 is consistent with the reported decline by the Tennessee Department of Education.

Multi-Regression Results

The multi-regression was used to respond to Component II and sub-question 4 mentioned earlier. In Table 6, TCAPMATHV refers to "Percentage of Students with Virtual Instruction and Scoring at the Proficient Level in TCAP Math Test in 2020-2021", TCAPENGLISH refers to "Percentage of Students with Face-to-Face Instruction at the Proficient Level in English in 2019-2020", TCAPMATHF2F refers to "Percentage of Students with Face-to-Face Instruction at the Proficient Level in Math in 2019-2020", ECON refers to "Economically Disadvantaged Counties

in Tennessee”(0 = no, 1 = yes), PERCENTPOC refers to “Percentage of People of Color in Tennessee Counties”, ACTALL refers to “2019-2020 Average ACT Math Scores Pertinent to Each School for All Students”, ACTPOC refers to “2019-2020 Average ACT Math Scores Pertinent to Each School for Black/Hispanic/Native American Students”, ACTECON refers to “2019-2020 Average ACT Math Scores Pertinent to Each School for Economically Disadvantaged Students”, and ACTDISAB refers to “2019-2020 Average ACT Math Scores Pertinent to Each School for Students with Disabilities”.

Table 6 *Multi-Regression*

Call:						
lm(formula = TCAPMATHV ~ TCAPENGLISH + TCAPMATHF2F + ECON + PERCENTPOC + ACTALL + ACTPOC + ACTECON + ACTDISAB)						
Residuals:						
Min	1Q	Median	3Q	Max		
-15.7242	-4.5963	-0.3763	3.8341	17.7321		
Coefficients:						
	Estimate	Std.Error	t value	Pr(>|t|)		
(Intercept)	22.91572	15.49721	1.479	0.141567		
TCAPENGLISH	0.06375	0.06194	1.029	0.305218		
TCAPMATHF2F	0.49173	0.05459	9.008	1.85E-15***		
ECON	-0.71125	1.42942	-0.498	0.619596		
PERCENTPOC	-0.15386	0.0447	-3.442	0.000771***		
ACTALL	0.06652	0.99085	0.067	0.946575		
ACTPOC	-0.42372	0.85952	-0.493	0.6228369		
ACTECON	-1.0807	1.35656	-0.797	0.427064		
ACTDISAB	0.43389	1.41759	0.306	0.760024		

Signif. codes:	0 '***'	0.001 '**'	0.01 '*'	0.05 '.'	0.1 ' '	1
Residual standard error: 6.528 on 134 degrees of freedom						
Multiple R-squared: 0.5701,	Adjusted R-squared: 0.5444					
F-statistics: 22.21 on 8 and 134 DF,	p-value: < 2.2E-16					

Using Multi-Regression analysis, the data in Table 6 pointed to the following specific result regarding research sub-question 4: There exists significant correlations between the dependent variable “Percentage of Students with Virtual Instruction and Scoring at the Proficient Level in TCAP Math Test” and the established independent variables, “Percentage of Students with Face-to-Face Instruction at the Proficient Level in Math in 2019-2020” and “Percentage of People of Color in Tennessee Counties” since the p-values for both of those variables were less than 0.001. As mentioned earlier, the null hypothesis that states “no significant correlation between the dependent variable and any of the independent variables” is rejected when the p-value is less than the designated significance level of 0.05.

The backward stepwise regression approach was used to reduce the number of independent variables and also the multicollinearity problem in order to obtain the best predictive model.

Table 7 *Backward Stepwise Regression*

Call:					
lm(formula = TCAPMATHV ~ TCAPMATHF2F + PERCENTPOC)					
Residuals:					
Min	1Q	Median	3Q	Max	
-14.6409	-4.6597	-0.7135	3.8129	16.8692	
Coefficients:					
	Estimate	Std.Error	t value	Pr(>|t|)	
(Intercept)	5.7383	1.34657	4.261	3.71E-05***	
TCAPMATHF2F	0.51279	0.03907	13.126	<2E-16***	
PERCENTPOC	-0.128	0.03897	-3.284	0.00129**	

Signif. codes:	0 '***'	0.001 '**'	0.01 '*'	0.05 '.'	0.1 ' ' 1
Residual standard error: 6.475 on 140 degrees of freedom					
Multiple R-squared: 0.5582	Adjusted R-squared: 0.5518				
F-statistics: 88.43 on 2 and 140 DF,	p-value: < 2.2E-16				

TCAPMATHV refers to “Percentage of Students with Virtual Instruction and Scoring at the Proficient Level in TCAP Math Test in 2020-2021”, TCAPMATHF2F refers to “Percentage of Students with Face-to-Face Instruction at the Proficient Level in Math in 2019-2020”, and PERCENTPOC refers to “Percentage of People of Color in Tennessee Counties”. Table 7 indicated that the p-value of “Percentage of Students with Face-to-Face Instruction at the Proficient Level in Math in 2019-2020” is less than 0.001 and the p-value of “Percentage of People of Color” is less than 0.01. Accordingly, these two variables are statistically significant in predicting “Percentage of Students with Virtual Instruction and Scoring at the Proficient Level in TCAP Math Test in 2020-2021”.

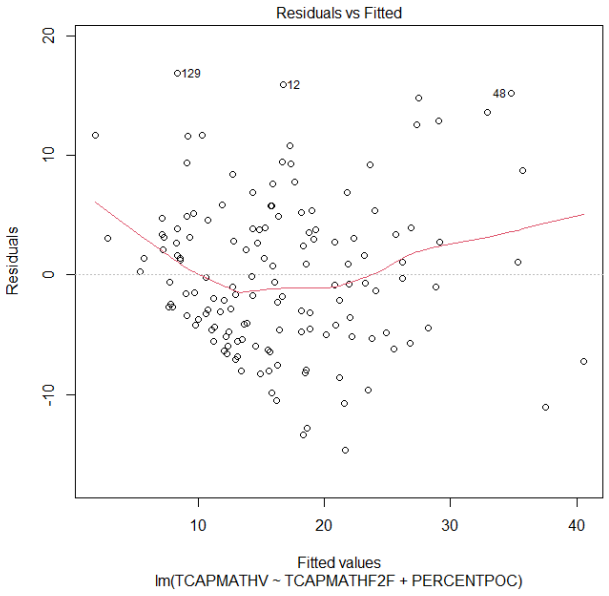
Based on Table 7, the following regression equation was formulated:

TCAPMATHV = 5.7383 + 0.51279 ×TCAPMATHF2F - 0.128 × PERCENTPOC

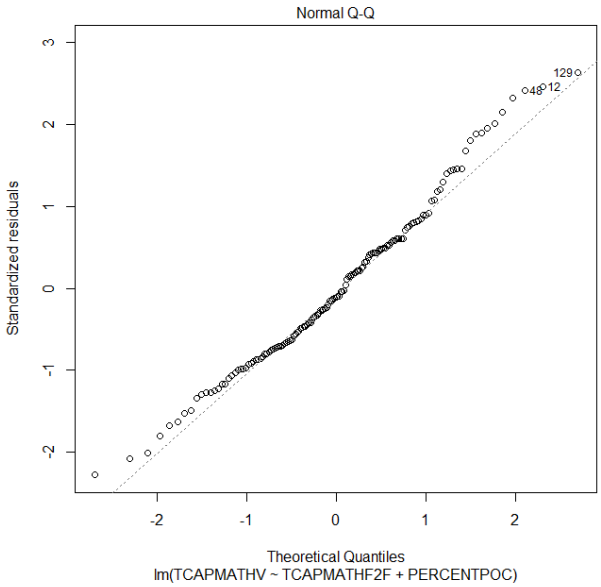
The predictive model indicates that TCAPMATHV increases by 0.5279 percentage points as TCAPMATHF2F increases by 1 percentage point and TCAPMATHV decreases by 0.128 percentage points as PERCENTPOC increases by 1 percentage point.

Table 7 also provides an additional result related to the adjusted coefficient of determination $R^2_{Adj} = 0.5518$. According to R^2_{Adj}, about 55.18% of the schools' percentages of students with virtual instruction and scoring at the proficient level in the TCAP math test can be explained by the schools' percentages of students with face-to-face instruction at the proficient level in math in 2019-2020 and the counties' percentages of people of color residing in Tennessee (Bluman 2019).

Plot 3 *Residuals vs Fitted*

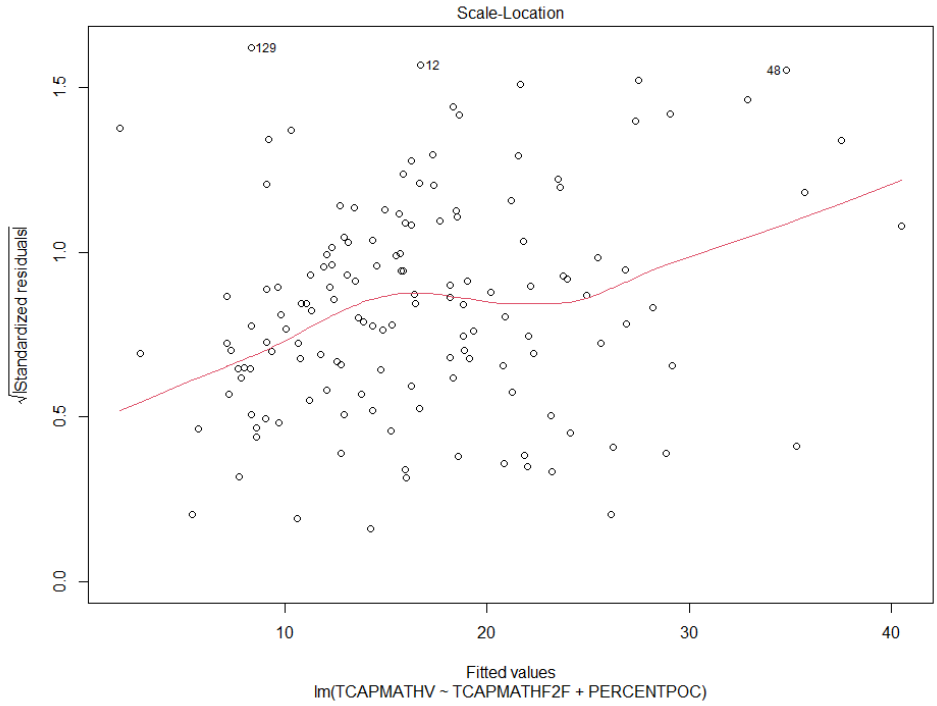


Plot 4 *Normal Q-Q*



Plot 3 showed no clear pattern, which can be considered that the linearity assumption was met. Plot 4 showed that the residuals follow a straight line to a great extent, which can be considered that the normality assumption was met.

Plot 5 *Scale-Location*



Plot 5 showed that the residual points are not all equally spaced out, which can be considered that the homoscedasticity assumption was violated.

Table 8 *Variance Inflation Factor (VIF)*

	TCAPMATHF2F	PERCENTPOC
VIF	1.007802	1.007802

Table 8 indicates that the multicollinearity assumption is met since the VIF values are less than 5. According to RDocumentation, a general guideline considers a VIF greater than 5 is large

which indicates that there will be inaccuracies estimating the coefficients in the model. Running the Durbin Watson Test indicated that the independence assumption was met since the p-value was greater than the designated 0.05 value for which the null hypothesis, that confirms the independence of errors, fails to be rejected. Since most of the multi-regression assumptions were met, the results regarding the regression model could be considered reliable.

Returning to the main research question of this study, the results presented in this chapter indicated that the academic performance of high school students in mathematics with virtual learning decreased by 9.6028 ± 2.7839 percentage points on the average from the academic performance of high school student in mathematics with face-to-face instruction. Furthermore, the proficiency rate of students with face-to-face learning and the percentage of people of color residing in the counties of the state where the sample was collected from were identified as the statistically significant contributing factors to the decrease in academic performance with virtual learning.

More precisely, the predictive model, TCAPMATHV = 5.7383 + 0.51279 × TCAPMATHF2F - 0.128 × PERCENTPOC, indicates that "Percentage of Students with Virtual Instruction and Scoring at the Proficient Level in TCAP Math Test in 2020-2021" increases by 0.5279 percentage points as "Percentage of Students with Face-to-Face Instruction at the Proficient Level in Math in 2019-2020" increases by 1 percentage point. Also, "Percentage of Students with Virtual Instruction and Scoring at the Proficient Level in TCAP Math Test in 2020-2021" decreases by 0.128 percentage points as "Percentage of People of Color in Tennessee Counties" increases by 1 percentage point.

Summary

The presentation and analysis tables and plots in this chapter played an essential role in addressing the two primary components of the research question:

I) Is there a significant difference in the academic performance in mathematics between high school students with virtual learning and students with face-to-face learning?

II) II) How does the academic performance in mathematics interrelate between high school students who receive virtual instruction and students who receive face-to-face instruction?

Furthermore, the presentation and analysis of tables and plots were also important in responding to the established research sub-questions:

1) Is there a significant difference in the mathematics TCAP proficiency rates of students between Tennessee public high schools' students with virtual instruction and Tennessee public high schools' students with traditional face-to-face instruction?

2) Is there a significant difference in the academic performance in mathematics between Tennessee public high schools' students residing in an economically disadvantaged county and Tennessee public high schools' students residing in a non-economically disadvantaged county?
3) Is there a significant interaction between the type of instruction and the economic status on the academic performance of Tennessee public high schools' students in mathematics?

4) Which of the 8 independent variables considered in this study are statistically significant in predicting the mathematics TCAP proficiency rates for Tennessee public high schools' students with virtual instruction?

Addressing the primary components of the research question and responding to research sub-questions helped in putting a reliable closure on the main research question that was under investigation in this study: To what extent does the academic performance in mathematics differ between high school students with virtual learning and students with traditional classroom face-to-face learning?

The following is a list of the findings of this study: a) There was a significant difference between the academic performance of high school students in mathematics with virtual instruction and students with traditional classroom face-to-face instruction; b) The difference was approximately 9.6 ± 2.8 percentage points indicating a decline in the academic performance of students with virtual instruction; c) The ratio of students scoring at the proficient level in mathematics with virtual instruction to students with face-to-face instruction was nearly 2 to 3; d) The statistically significant contributing factors to the difference in the academic performance between students with virtual instruction and face-to-face instruction were TCAP math school's proficiency rate of students with face-to-face instruction and the percentage of people of color in the school's district; and e) A predictive model was obtained, and the model was: $TCAPMATHV = 5.7383 + 0.51279 \times TCAPMATHF2F - 0.128 \times PERCENTPOC$, indicating an increase of approximately 0.51 and a decrease of 0.13 percentage points in TCAPMATHV for each percentage point increase in TCAPMATHF2F and PERCENTPOC respectively.

Chapter 5 – Summarizing and Discussing the Results

Introduction

The final chapter of this thesis restates the research problem and reviews the methodology used in the study in order to collect data and obtain results for research analysis. The fundamental sections of this chapter summarize the results and conclusions, state the findings of the study, provide implications of the study, and offer recommendations for future research. The motivation for this study was due to the COVID-19 pandemic country shutdown, and consequently school shutdown, where teaching and learning took place via the internet and using the virtual instructional delivery method. As was reported in the news and media, the academic performance of high school students declined with virtual learning.

Statement of the Problem

As stated in Chapter 1, the purpose of this study was to investigate the extent to which the academic performance in mathematics differs between high school students with virtual learning and students with traditional classroom face-to-face learning. Responding to the research question was done by addressing the following two primary components (I and II) of the research question accompanied by specific research sub-questions (1-4):

I) Is there a significant difference in the academic performance in mathematics between high school students with virtual learning and students with face-to-face learning?

II) How does the academic performance in mathematics interrelate between high school students who receive virtual instruction and students who receive face-to-face instruction?

1) Is there a significant difference in the mathematics TCAP proficiency rates of students between Tennessee public high schools' students with virtual instruction and Tennessee public high schools' students with traditional face-to-face instruction?

2) Is there a significant difference in the academic performance in mathematics between Tennessee public high schools' students residing in an economically disadvantaged county and Tennessee public high schools' students residing in a non-economically disadvantaged county?
3) Is there a significant interaction between the type of instruction and the economic status on the academic performance of Tennessee public high schools' students in mathematics?
4) Which of the 8 independent variables considered in this study are statistically significant in predicting the mathematics TCAP proficiency rates for Tennessee public high schools' students with virtual instruction?

Review of Methodology

Carrying out the study was done by proceeding according to an established framework. As reported in Chapter 1, the results for this study were obtained by using two-way ANOVA followed by multi-regression. An experimental design was established for a sample of 143 public high schools in Tennessee where students are required to take standardized tests, known as the TCAP test, at the end of each school year. The collected data were specific to standardized tests scores in math courses for the school years 2019-2020 and 2020-2021, where the students received their learning in the traditional classroom face-to-face setting in 2019-2020 while the instructional delivery modality was virtual in 2020-2021 due to the COVID-19 pandemic

shutdown. More data were collected, and these data were specific to standardized tests scores in the English subject for the school year 2019-2020, economic status of Tennessee's counties, counties' percentages of people of color, and the 2019-2020 average ACT math scores pertinent to various classifications of students.

Summary of Results and Conclusions

The following are two major results presented in Chapter 4:

(a) There is a significant difference between the means of "Percentage of Students Scoring at the Proficient Level in TCAP Math Tests" across students using virtual instruction and students using face-to-face instruction.

(b) The "Percentage of Students with Face-to-Face Instruction at the Proficient Level in Math in 2019-2020" and the "Percentage of People of Color" are statistically significant in predicting "Percentage of Students with Virtual Instruction and Scoring at the Proficient Level in TCAP Math Test in 2020-2021".

Findings of the Study

The study concerning the impact of visual instruction on the academic performance of high school students in mathematics indicated the following major findings:

1) A significant difference in the academic performance in mathematics existed between high school students with virtual learning and students with traditional classroom face-to-face learning, regardless of their economic status. The difference indicated a decline in the rate of students achieving proficient academic performance (meets grade level expectation) in mathematics with the virtual instruction method by approximately 9.6028 ± 2.7839 percentage points from the rate of students achieving proficient academic

performance in mathematics with the traditional classroom face-to-face instructional delivery method. According to the Tennessee Department of Education website, the statewide overall student proficiency in math declined by 12 percentage points with virtual instruction for a total of over 1,800 public schools, from grade 3 through grade 12. This indicates that the difference in the means obtained from this study is consistent with the reported decline by the Tennessee Department of Education.

2) A significant positive correlation existed between the academic performance in mathematics of high school students receiving virtual instruction and students receiving traditional classroom face-to-face instruction. Additionally, a significant negative correlation existed between the academic performance in mathematics in high school students receiving virtual instruction and the people of color constituent.
    a. The positive correlation indicated an increase in the rate of proficient academic performance in mathematics for students with the virtual instruction method by approximately 0.51279 percentage points for each percentage point increase in the rate of proficient academic performance in mathematics for students with the face-to-face instruction delivery method .
    b. The negative correlation indicated a decrease in the rate of proficient academic performance in mathematics with the virtual instruction method by approximately 0.128 percentage points for each percentage point increase in the people of color constituent.
3) Based on the identified correlations, a mathematical model was found to express the relationship that existed between the academic performance in mathematics of high school students with virtual instruction and the two predictors: (i) the academic

performance in mathematics of high school students with traditional classroom face-to-face instruction and (ii) the people of color constituent. This relationship was specific to the rate of students achieving proficient academic performance in mathematics with virtual instruction, the rate of students achieving proficient academic performance in mathematics with face-to-face instruction, and the percentage of people of color constituent. The explicit predictive mathematical model identified with the following formulated relationship: Rate of students achieving proficient academic performance in mathematics of high school students with virtual learning $\approx 5.7383 + 0.51279 \times$ Rate of students achieving proficient academic performance in mathematics of high school students with face-to-face learning $- 0.128 \times$ Percentage of people of color constituent.

In comparison with the findings reported in the literature review chapter of the study, the findings of this study agreed with the findings of similar studies in the majority of cases, but in the meantime, they differed from the findings of similar studies in a few cases.

Implications of the Study

The methodology and statistical design used for this study resulted in reliable and valid conclusions. The results reported in this study provided evidence to support the credibility of virtual instruction and the integrity of the virtual type of instructional delivery. Although the data pointed to a decrease in learning high school level mathematics, there was evidence that nearly two-thirds (63.4%) of the portion of students who achieved proficient performance in mathematics with face-to-face instruction demonstrated proficient performance in mathematics with virtual instruction.

The theoretical implications here was that educators and stakeholders can make use of the viability of virtual type setting and the implementation of it for instructional delivery. Incorporating this instructional delivery modality in the teaching and learning theories aligns with the fundamentals of the theories since all teaching and learning theory models presented in the theoretical framework for this study already include a contributing aspect to the design of online materials in unique ways (Chittaro and Ranon 2007). The connectivism teaching and learning theory in particular integrates technology in the model that it offers to educators. The use of technology allows teachers to create an interactive and realistic environment with a combination of 3D interactive graphics and web technologies not only in a traditional face-to-face classroom, but also for students in an online setting (Chittaro and Rannon 2007).

Regarding the practical implications of the study reported here, the option of virtual type setting implementation and utilization opens the doors for many students who think together with their parents that the virtual high school setting is the right choice for them. This option allows for high school students to get ready for post-secondary high school online learning, get prepared for college dual enrollment in online classes, virtual home schooling, virtual tutoring, accelerated and self-paced learning, flexibility of schedule, and earning a high school diploma quicker (Gaitle 2018). For lower achieving students and lower academically performing students in mathematics with virtual instruction such as some students from the people of color as was reported in this study, the virtual setting option still works when online course design and instructional technology, as well as interventions, are strategically implemented to support their success (Wrenn 2015). The predictive model for this study indicated a rate of 12.8% decrease in the portion of students who achieved proficient performance in mathematics with virtual instruction associates with the people of color constituents.

The option of the virtual high school setting also allows for educational administrators and policymakers to making informed decisions about online learning and its potential impact on educational productivity. This includes, but is not limited to, options such as broadening access in ways that reduce the costs of providing educational resources and experiences, making better use of teacher and student time, reducing school-based facilities cost by utilizing home and community public places in addition to usual school building, and reducing salary costs by reallocating some educational activities to computers and by increasing student to teacher ratios (Bakia, Shear, Toyama, Lasseter 2012). Furthermore, this option of virtual instructional delivery will be fully utilized and fill in the gap in case of school closings and emergencies, inevitable school shut down, and lock down or safer-at-home orders

Recommendations for Future Research

The following are some recommendations for further investigation that could complement the findings of this study on the issue of the impact of virtual instruction on the academic performance of high school students in mathematics: (i) replicate the study for other subjects taught in high school, (ii) replicate the study for all subjects and grade levels K-12, (iii) replicate the study by using grade point average (GPA), class activities, tests and homework, and traditional grading schemes and grade scales as measures of student academic performance instead of standardized tests and examine the grade inflation controversy, and (iv) replicate the study by sampling only one school and using student-by-student actual standardized test scores instead of school-by-school proficiency rate. These recommendations would assist in building on this research and closing more gaps that were not filled in by the results of this study due to the existing limitations mentioned in chapter 1.

Summary

In a nutshell, the findings of this study indicated that there is a significant difference in the academic performance in mathematics between high school students with virtual learning and students with face-to-face learning. The academic performance of students with virtual learning was lower than that of students with face-to-face learning. The findings also indicated significant correlations between the dependent variable and two of the independent variables considered in this study. The explicit predictive model was identified as follows:

$$TCAPMATHV = 5.7383 + 0.51279 \times TCAPMATHF2F - 0.128 \times PERCENTPOC$$

The findings of this study agreed with findings of similar studies regarding the decreased academic performance of high school students in the mathematics subject when delivered virtually as compared with the traditional face-to-face instructional delivery type. However, the findings of the study about the decreased academic performance with virtual learning did not agree with findings of similar studies conducted for the English subject in high schools. Inasmuch as this study agreed with, differed from, and added to other studies on the impact of virtual instruction on the academic performance of high school students in mathematics, it is still wide open for researchers to further investigate the issue and shed light on it.

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Appendix A

Regression Data Summary

School Code	County Code	TCAPMATHV	TCAPMATHF2F	TCAPENGLISHF2F	ECONDIS	PERCENTPOC
School # 1	County # 1	13.4	27.6	37	0	13.3
School # 2	County # 1	15.6	17.1	34.3	0	13.3
School # 3	County # 2	6.3	10.6	32.1	1	8.7
School # 4	County # 2	29	41	35.5	1	8.7
School # 5	County # 3	18.2	19.7	26.1	0	11.8
School # 6	County # 3	16.6	21.5	35.8	0	11.8
School # 7	County # 3	23.1	29.5	36	0	11.8
School # 8	County # 3	46.5	55.9	58.8	0	11.8
School # 9	County # 4	7.5	10.9	32	0	17.6
School # 10	County # 5	14.8	10.1	26.6	0	9.8
School # 11	County # 6	11.3	15.9	36.4	1	7.4
School # 12	County # 7	32.6	25.3	32.1	1	15.6
School # 13	County # 7	7.6	23.2	26.7	1	15.6
School # 14	County # 6	15.2	30	32.4	1	7.4
School # 15	County # 8	26.1	25.2	31.9	0	15.7
School # 16	County # 9	11.9	22.4	37.2	1	5.8
School # 17	County # 9	9.2	20.5	20.8	1	5.8
School # 18	County # 10	9.7	15.4	25.5	1	8.3
School # 19	County # 10	6.3	16.5	22.1	1	8.3
School # 20	County # 11	8.1	21.7	24.1	0	26.4
School # 21	County # 12	28.1	24.3	32.1	0	7
School # 22	County # 12	18.5	33.6	41	0	7
School # 23	County # 13	26.5	73	89.1	0	44
School # 24	County # 13	5.9	5.4	21.6	0	44
School # 25	County # 14	26.7	24.6	23.6	0	7.6
School # 26	County # 15	11.8	16.6	24.9	0	11.5
School # 27	County # 16	23.6	23	40.3	0	12.3
School # 28	County # 16	5.7	15.4	36.4	0	12.3
School # 29	County # 17	21.1	46.7	35.3	0	22.3
School # 30	County # 17	22.8	41.4	45.3	0	22.3
School # 31	County # 18	17.8	20.5	22.7	0	33.7
School # 32	County # 19	5.7	26.5	24	0	24.1
School # 33	County # 19	24.8	40	44.2	0	24.1
School # 34	County # 19	44.5	64.5	50.9	0	24.1
School # 35	County # 20	7.5	18.6	28.3	0	17.1
School # 36	County # 21	5	26.3	22.1	1	6.8
School # 37	County # 22	18.6	20	31.1	1	9
School # 38	County # 22	14.3	27.8	24	1	9
School # 39	County # 22	28.7	33.6	45.1	1	9

School Code	County Code	TCAPMATHV	TCAPMATHF2F	TCAPENGLISHF2F	ECONDIS	PERCENTPOC
School # 40	County # 22	5.7	8.8	20.2	1	9
School # 41	County # 22	41.9	47.7	41.5	1	9
School # 42	County # 23	12.5	12.2	25.8	0	20.6
School # 44	County # 24	5.7	7	25.9	0	30.4
School # 45	County # 24	27.9	52.7	71.8	0	30.4
School # 46	County # 24	15.7	33.2	43.9	0	30.4
School # 47	County # 24	7.1	11.5	18.3	0	30.4
School # 48	County # 24	50	64.3	91.7	0	30.4
School # 49	County # 24	21.6	27.3	26.3	0	30.4
School # 50	County # 24	9.3	10.5	32.2	0	30.4
School # 51	County # 24	10.5	10.7	21.4	0	30.4
School # 52	County # 24	31.9	53.3	34.6	0	30.4
School # 53	County # 24	42.3	50	64.9	0	30.4
School # 54	County # 24	7	38.6	43.3	0	30.4
School # 55	County # 25	9.8	16.7	16	1	44.7
School # 56	County # 26	21.3	23	20.6	1	8.8
School # 57	County # 27	16.7	21.5	27.8	1	6.3
School # 58	County # 27	19.2	20.2	29.4	1	6.3
School # 59	County # 28	16.7	32.9	41.1	1	13.5
School # 60	County # 28	20	32.8	38.9	1	13.5
School # 61	County # 29	10	7.8	28.3	1	8.8
School # 62	County # 30	5.4	6.4	42.1	0	9.1
School # 63	County # 30	9.3	13	33.8	0	9.1
School # 64	County # 31	10.8	33.2	38.8	0	9.4
School # 65	County # 32	8.2	12.9	56	0	20.8
School # 66	County # 32	10.5	7.9	24	0	20.8
School # 67	County # 32	23.6	34.6	58.7	0	20.8
School # 68	County # 32	5.3	9.6	31.5	0	20.8
School # 69	County # 33	5.8	35.1	31.5	1	39.8
School # 70	County # 33	7.8	19.7	18.7	1	39.8
School # 71	County # 34	5.7	14.8	30.7	0	7.8
School # 72	County # 34	12.6	32.1	31.2	0	7.8
School # 73	County # 34	32.8	36.8	31.2	0	7.8
School # 74	County # 35	5.9	17.2	26.1	0	12.6
School # 75	County # 36	14.1	19.4	27.7	1	11.1
School # 76	County # 37	20.8	9.2	19.7	0	9.6
School # 77	County # 38	11.9	14	46	0	45.1
School # 78	County # 38	10.4	20.8	13.7	0	45.1
School # 79	County # 39	6.5	13	30	0	10.3
School # 80	County # 39	7	13.5	20	0	10.3
School # 81	County # 39	11	7.6	31.1	0	10.3
School # 82	County # 40	7.1	5.7	18	0	22.9

School Code	County Code	TCAPMATHV	TCAPMATHF2F	TCAPENGLISHF2F	ECONDIS	PERCENTPOC
School # 83	County # 41	10.3	26.5	29.1	1	6.8
School # 84	County # 42	19.5	27.5	27.7	1	9.9
School # 85	County # 42	21.1	16.1	16.5	1	9.9
School # 87	County # 42	22.4	28	30.1	1	9.9
School # 88	County # 43	6.4	22.2	47.8	0	37.4
School # 89	County # 43	5.6	17.3	35.6	0	37.4
School # 90	County # 43	9.5	24.7	49.2	0	37.4
School # 91	County # 43	5	13.1	35.2	0	37.4
School # 92	County # 44	18.5	11.2	29.2	1	18.5
School # 93	County # 44	10	9.7	19.6	1	18.5
School # 94	County # 45	24.4	28.9	30.7	1	11.8
School # 95	County # 46	23.4	26.6	40	0	9.3
School # 96	County # 46	15.4	22.4	22.7	0	9.3
School # 97	County # 47	12.6	21.7	21.9	0	19.7
School # 98	County # 47	15.4	14.8	23.5	0	19.7
School # 99	County # 47	5.7	15.7	12.2	0	19.7
School # 100	County # 47	21.2	36.6	32	0	19.7
School # 101	County # 48	20.8	27.8	28.1	0	12.9
School # 102	County # 48	29.4	38.8	42.7	0	12.9
School # 103	County # 49	13.5	8.6	40.7	0	64.9
School # 104	County # 49	18.5	51.4	29.7	0	64.9
School # 105	County # 49	22	25.1	48.6	0	64.9
School # 106	County # 49	14	22.8	45.8	0	64.9
School # 107	County # 49	10	28.6	44.6	0	64.9
School # 108	County # 49	7.4	25.8	60.7	0	64.9
School # 109	County # 49	5.4	31.2	55	0	64.9
School # 110	County # 50	6	21.9	30.6	0	8.7
School # 111	County # 50	9.9	18.1	26.6	0	8.7
School # 112	County # 50	21.3	19	41.8	0	8.7
School # 113	County # 46	22.5	36.4	45.1	0	9.3
School # 114	County # 51	19.1	35.1	43.4	0	19.5
School # 115	County # 51	14.9	26.2	31	0	19.5
School # 116	County # 51	30.8	46.1	40.8	0	19.5
School # 117	County # 51	17.4	22.4	25.4	0	19.5
School # 118	County # 51	25.9	44.7	48.7	0	19.5
School # 119	County # 51	25.4	37.2	42.1	0	19.5
School # 120	County # 51	14	25.4	28.8	0	19.5
School # 121	County # 52	15.9	22.1	37.6	0	25.5
School # 122	County # 52	8.6	23.5	27.8	0	25.5
School # 123	County # 52	21.5	25.9	37.3	0	25.5
School # 124	County # 53	7.1	14.8	29.9	1	8.6
School # 125	County # 54	7.7	16.8	21.3	1	15

School Code	County Code	TCAPMATHV	TCAPMATHF2F	TCAPENGLISHF2F	ECONDIS	PERCENTPOC
School # 126	County # 55	22.8	35	39.2	0	14.3
School # 127	County # 55	25.4	26.8	33.2	0	14.3
School # 128	County # 55	36.4	61.3	51.8	0	14.3
School # 129	County # 56	25.2	8.7	23.9	0	14.6
School # 130	County # 57	15.2	28.7	73.4	0	17.8
School # 131	County # 57	10.6	29.4	53.9	0	17.8
School # 132	County # 57	8.7	16.2	32.5	0	17.8
School # 133	County # 57	39.9	46.6	67.2	0	17.8
School # 134	County # 57	17	36.5	65.6	0	17.8
School # 135	County # 57	19.3	43	57.8	0	17.8
School # 136	County # 57	27.3	44.4	73.8	0	17.8
School # 137	County # 57	23.8	48.3	63.5	0	17.8
School # 138	County # 57	33.3	72.3	69.9	0	17.8
School # 139	County # 57	9.3	23.9	52.7	0	17.8
School # 140	County # 58	8.7	25.1	31.6	0	18.2
School # 141	County # 58	20.1	42	50	0	18.2
School # 142	County # 58	6.7	22.5	29.5	0	18.2
School # 143	County # 58	13.9	39.2	40.4	0	18.2

School Code	County Code	ACTALLF2F	ACTPOCF2F	ACTECONF2F	ACTDISABF2F
School # 1	County # 1	18.4	17.4	17.2	15
School # 2	County # 1	18.4	17.4	17.2	15
School # 3	County # 2	19.1	17.3	18	16
School # 4	County # 2	19.1	17.3	18	16
School # 5	County # 3	18.9	17.6	17	15.1
School # 6	County # 3	18.9	17.6	17	15.1
School # 7	County # 3	20.6	18.3	17	15.8
School # 8	County # 3	23.6	19.5	18.8	17
School # 9	County # 4	19.1	16.6	17.7	15.6
School # 10	County # 5	18.5	16.3	17.5	15.6
School # 11	County # 6	18.1	15.4	16.2	15.1
School # 12	County # 7	19.8	18.5	17.8	14.6
School # 13	County # 7	18.4	18.5	18.3	15.6
School # 14	County # 6	19.4	15.3	17.6	14.5
School # 15	County # 8	19.1	18	17.9	15.4
School # 16	County # 9	18.1	19.3	16.9	14.7
School # 17	County # 9	18.1	19.3	16.9	14.7
School # 18	County # 10	17.6	16.2	16.7	15
School # 19	County # 10	17.6	16.2	16.7	15
School # 20	County # 11	17.8	16.4	16.9	14.8
School # 21	County # 12	19.6	16.5	17.8	16.1
School # 22	County # 12	19.6	16.5	17.8	16.1
School # 23	County # 13	17.9	16.7	16.7	15.4
School # 24	County # 13	17.9	16.7	16.7	15.4
School # 25	County # 14	17.9	16.2	17.1	15.3
School # 26	County # 15	18.6	15.8	17.4	15
School # 27	County # 16	18.9	17.1	17.1	15.5
School # 28	County # 16	18.9	17.1	17.1	15.5
School # 29	County # 17	19.3	16.8	18.1	15.8
School # 30	County # 17	21	17.8	17.7	15.8
School # 31	County # 18	16.7	16.2	16.2	14.8
School # 32	County # 19	19.7	17	18.7	16.2
School # 33	County # 19	20.5	17.1	18.2	15.8
School # 34	County # 19	20.5	17.1	18.2	15.8
School # 35	County # 20	18.1	16.6	17.4	14.8
School # 36	County # 21	17.9	16.6	17.1	14.5
School # 37	County # 22	18.2	16.9	17.4	15.1
School # 38	County # 22	18.2	16.9	17.4	15.1
School # 39	County # 22	18.2	16.9	17.4	15.1
School # 40	County # 22	18.2	16.9	17.4	15.1

School Code	County Code	ACTALLF2F	ACTPOCF2F	ACTECONF2F	ACTDISABF2F
School # 41	County # 22	21.7	18.9	18.9	18.7
School # 42	County # 23	19.5	18.4	17.6	15.4
School # 43	County # 23	19.5	18.4	17.6	15.4
School # 44	County # 24	19.1	16.9	16.9	15.9
School # 45	County # 24	19.1	16.9	16.9	15.9
School # 46	County # 24	19.1	16.9	16.9	15.9
School # 47	County # 24	19.1	16.9	16.9	15.9
School # 48	County # 24	19.1	16.9	16.9	15.9
School # 49	County # 24	19.1	16.9	16.9	15.9
School # 50	County # 24	19.1	16.9	16.9	15.9
School # 51	County # 24	19.1	16.9	16.9	15.9
School # 52	County # 24	19.1	16.9	16.9	15.9
School # 53	County # 24	19.1	16.9	16.9	15.9
School # 54	County # 24	19.1	16.9	16.9	15.9
School # 55	County # 25	17.4	16.1	16.3	14.3
School # 56	County # 26	17.9	15.1	16.9	15.2
School # 57	County # 27	18.2	16.6	17.1	15.2
School # 58	County # 27	18.2	16.6	17.1	15.2
School # 59	County # 28	20.1	17.9	18.2	16.3
School # 60	County # 28	20.1	17.9	18.2	16.3
School # 61	County # 29	18	16.6	16.3	16.2
School # 62	County # 30	18.4	16	16.8	15.2
School # 63	County # 30	18.4	16	16.8	15.2
School # 64	County # 31	19.4	17.2	18	15.1
School # 65	County # 32	20.2	17.3	17.3	15.8
School # 66	County # 32	20.2	17.3	17.3	15.8
School # 67	County # 32	20.2	17.3	17.3	15.8
School # 68	County # 32	20.2	17.3	17.3	15.8
School # 69	County # 33	17.3	16.1	16.1	14.7
School # 70	County # 33	17.3	16.1	16.1	14.7
School # 71	County # 34	18.5	17	16.9	14.7
School # 72	County # 34	18.5	17	16.9	14.7
School # 73	County # 34	18.5	17	16.9	14.7
School # 74	County # 35	18.7	17.8	17.5	15.2
School # 75	County # 36	18.3	16.4	17.5	14.8
School # 76	County # 37	18.4	18.7	17.6	14.4
School # 77	County # 38	17.2	16.1	15.9	14.4
School # 78	County # 38	17.2	16.1	15.9	14.4
School # 79	County # 39	17.9	17.1	16.9	15.1
School # 80	County # 39	17.9	17.1	16.9	15.1
School # 81	County # 39	17.9	17.1	16.9	15.1

School Code	County Code	ACTALLF2F	ACTPOCF2F	ACTECONF2F	ACTDISABF2F
School # 82	County # 40	18.4	16.5	16.7	15.3
School # 83	County # 41	18.2	16.2	17.9	15
School # 84	County # 42	18.1	16.1	16.7	14.9
School # 85	County # 42	18.1	16.1	16.7	14.9
School # 86	County # 42	18.1	16.1	16.7	14.9
School # 87	County # 42	18.1	16.1	16.7	14.9
School # 88	County # 43	19.2	17.7	17.4	15.4
School # 89	County # 43	19.2	17.7	17.4	15.4
School # 90	County # 43	19.2	17.7	17.4	15.4
School # 91	County # 43	19.2	17.7	17.4	15.4
School # 92	County # 44	18.2	15.7	16.7	15.3
School # 93	County # 44	18.2	15.7	16.7	15.3
School # 94	County # 45	18.7	18.2	17.8	15.8
School # 95	County # 46	19.1	18.2	17.8	15.5
School # 96	County # 46	19.1	18.2	17.8	15.5
School # 97	County # 47	19.2	17.3	17.4	15.6
School # 98	County # 47	19.2	17.3	17.4	15.6
School # 99	County # 47	19.2	17.3	17.4	15.6
School # 100	County # 47	19.2	17.3	17.4	15.6
School # 101	County # 48	18.9	17.4	17.4	15.4
School # 102	County # 48	18.9	17.4	17.4	15.4
School # 103	County # 49	17	16.6	16.1	15.1
School # 104	County # 49	17	16.6	16.1	15.1
School # 105	County # 49	17	16.6	16.1	15.1
School # 106	County # 49	21.4	19.8	18.8	17.2
School # 107	County # 49	20.2	18.6	18.4	15.8
School # 108	County # 49	23.5	19.7	17	17.2
School # 109	County # 49	24	21.3	21.6	18.2
School # 110	County # 50	18.9	17.3	17.4	15.1
School # 111	County # 50	18.9	17.3	17.4	15.1
School # 112	County # 50	18.9	17.3	17.4	15.1
School # 113	County # 46	21.8	18.4	18.4	15.9
School # 114	County # 51	20.1	18	18	16.1
School # 115	County # 51	20.1	18	18	16.1
School # 116	County # 51	20.1	18	18	16.1
School # 117	County # 51	20.1	18	18	16.1
School # 118	County # 51	20.1	18	18	16.1
School # 119	County # 51	20.1	18	18	16.1
School # 120	County # 51	20.1	18	18	16.1
School # 121	County # 52	19.8	17.6	17.7	15.8
School # 122	County # 52	19.8	17.6	17.7	15.8

School Code	County Code	ACTALLF2F	ACTPOCF2F	ACTECONF2F	ACTDISABF2F
School # 124	County # 53	18.1	16.6	17	15.1
School # 125	County # 54	17.8	16.3	16.6	15.3
School # 126	County # 55	19.3	18.3	17.4	15.5
School # 127	County # 55	19.3	18.3	17.4	15.5
School # 128	County # 55	22.1	18.7	18.6	15.5
School # 129	County # 56	19.5	16.7	18	15.3
School # 130	County # 57	24.2	21	19.6	17.8
School # 131	County # 57	24.2	21	19.6	17.8
School # 132	County # 57	24.2	21	19.6	17.8
School # 133	County # 57	24.2	21	19.6	17.8
School # 134	County # 57	24.2	21	19.6	17.8
School # 135	County # 57	24.2	21	19.6	17.8
School # 136	County # 57	24.2	21	19.6	17.8
School # 137	County # 57	24.2	21	19.6	17.8
School # 138	County # 57	24.2	21	19.6	17.8
School # 139	County # 57	24.2	21	19.6	17.8
School # 140	County # 58	20.2	18	17.7	16.5
School # 141	County # 58	20.2	18	17.7	16.5
School # 142	County # 58	20.2	18	17.7	16.5
School # 143	County # 58	20.2	18	17.7	16.5

Appendix B

Two-Way ANOVA Data Summary

(Pulled from the Regression Data Summary)

Percentage of Students TCAP MATH	Instruction	Economically Disadvantaged
6.3	V	Yes
29	V	Yes
11.3	V	Yes
32.6	V	Yes
7.6	V	Yes
15.2	V	Yes
11.9	V	Yes
9.2	V	Yes
9.7	V	Yes
6.3	V	Yes
5	V	Yes
18.6	V	Yes
14.3	V	Yes
28.7	V	Yes
5.7	V	Yes
41.9	V	Yes
9.8	V	Yes
21.3	V	Yes
16.7	V	Yes
19.2	V	Yes
16.7	V	Yes
20	V	Yes
10	V	Yes
5.8	V	Yes
7.8	V	Yes
14.1	V	Yes
10.3	V	Yes
19.5	V	Yes
21.1	V	Yes
22.1	V	Yes
22.4	V	Yes
18.5	V	Yes
10	V	Yes
24.4	V	Yes
7.1	V	Yes
7.7	V	Yes
10.6	F	Yes

Percentage of Students TCAP MATH	Instruction	Economically Disadvantaged
15.9	F	Yes
25.3	F	Yes
23.2	F	Yes
30	F	Yes
22.4	F	Yes
20.5	F	Yes
15.4	F	Yes
16.5	F	Yes
26.3	F	Yes
20	F	Yes
27.8	F	Yes
33.6	F	Yes
8.8	F	Yes
47.7	F	Yes
16.7	F	Yes
23	F	Yes
21.5	F	Yes
20.2	F	Yes
32.9	F	Yes
32.8	F	Yes
7.8	F	Yes
35.1	F	Yes
19.7	F	Yes
19.4	F	Yes
26.5	F	Yes
27.5	F	Yes
16.1	F	Yes
28.6	F	Yes
28	F	Yes
11.2	F	Yes
9.7	F	Yes
28.9	F	Yes
14.8	F	Yes
16.8	F	Yes
13.4	V	No
15.6	V	No
18.2	V	No
16.6	V	No
23.1	V	No
46.5	V	No
7.5	V	No
14.8	V	No

Percentage of Students TCAP MATH	Instruction	Economically Disadvantaged
8.1	V	No
28.1	V	No
18.5	V	No
26.5	V	No
5.9	V	No
26.7	V	No
11.8	V	No
23.6	V	No
5.7	V	No
21.1	V	No
22.8	V	No
17.8	V	No
5.7	V	No
24.8	V	No
44.5	V	No
7.5	V	No
12.5	V	No
12.2	V	No
5.7	V	No
27.9	V	No
15.7	V	No
7.1	V	No
50	V	No
21.6	V	No
9.3	V	No
10.5	V	No
31.9	V	No
42.3	V	No
7	V	No
5.4	V	No
9.3	V	No
10.8	V	No
8.2	V	No
10.5	V	No
23.6	V	No
5.3	V	No
5.7	V	No
12.6	V	No
32.8	V	No
5.9	V	No
20.8	V	No
11.9	V	No

Percentage of Students TCAP MATH	Instruction	Economically Disadvantaged
6.5	V	No
7	V	No
11	V	No
7.1	V	No
6.4	V	No
5.6	V	No
9.5	V	No
5	V	No
23.4	V	No
15.4	V	No
12.6	V	No
15.4	V	No
5.7	V	No
21.2	V	No
20.8	V	No
29.4	V	No
13.5	V	No
18.5	V	No
22	V	No
14	V	No
10	V	No
7.4	V	No
5.4	V	No
6	V	No
9.9	V	No
21.3	V	No
22.5	V	No
19.1	V	No
14.9	V	No
30.8	V	No
17.4	V	No
25.9	V	No
25.4	V	No
14	V	No
15.9	V	No
8.6	V	No
21.5	V	No
22.8	V	No
25.4	V	No
36.4	V	No
25.2	V	No
15.2	V	No

Percentage of Students TCAP MATH	Instruction	Economically Disadvantaged
8.7	V	No
39.9	V	No
17	V	No
19.3	V	No
27.3	V	No
23.8	V	No
33.3	V	No
9.3	V	No
8.7	V	No
20.1	V	No
6.7	V	No
13.9	V	No
27.6	F	No
17.1	F	No
19.7	F	No
21.5	F	No
29.5	F	No
55.9	F	No
10.9	F	No
10.1	F	No
25.2	F	No
21.7	F	No
24.3	F	No
33.6	F	No
73	F	No
5.4	F	No
24.6	F	No
16.6	F	No
23	F	No
15.4	F	No
46.7	F	No
41.4	F	No
20.5	F	No
26.5	F	No
40	F	No
64.5	F	No
18.6	F	No
12.2	F	No
10.2	F	No
7	F	No
52.7	F	No
33.2	F	No

Percentage of Students TCAP MATH	Instruction	Economically Disadvantaged
64.3	F	No
27.3	F	No
10.5	F	No
10.7	F	No
53.3	F	No
50	F	No
38.6	F	No
6.4	F	No
13	F	No
33.2	F	No
12.9	F	No
7.9	F	No
34.6	F	No
9.6	F	No
14.8	F	No
32.1	F	No
36.8	F	No
17.2	F	No
9.2	F	No
14	F	No
20.8	F	No
13	F	No
13.5	F	No
7.6	F	No
5.7	F	No
22.2	F	No
17.3	F	No
24.7	F	No
13.1	F	No
26.6	F	No
22.4	F	No
21.7	F	No
14.8	F	No
15.7	F	No
36.6	F	No
27.8	F	No
38.8	F	No
8.6	F	No
51.4	F	No
25.1	F	No
22.8	F	No
28.6	F	No

Percentage of Students TCAP MATH	Instruction	Economically Disadvantaged
31.2	F	No
21.9	F	No
18.1	F	No
19	F	No
36.4	F	No
35.1	F	No
26.2	F	No
46.1	F	No
22.4	F	No
44.7	F	No
37.2	F	No
25.4	F	No
22.1	F	No
23.5	F	No
25.9	F	No
35	F	No
26.8	F	No
61.3	F	No
8.7	F	No
28.7	F	No
29.4	F	No
16.2	F	No
46.6	F	No
36.5	F	No
43	F	No
44.4	F	No
48.3	F	No
72.3	F	No
23.9	F	No
25.1	F	No
42	F	No
22.5	F	No
39.2	F	No

Bibliography

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