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Play Lu Interactive Technology and Standardized Mathematics Scores

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Abstract

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Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

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Abstract

Technology-based learning tools provide new opportunities to engage students in learning academic content. This study focuses on one such tool, Play Lu Interactive Technology (PLIT), and analyzes how students' math achievement on standardized test scores differs between students who have used PLIT and students who have not. PLIT is designed to improve students' communication and teamwork skills in addition to math skills. The data were collected from seventh-grade students at a public school in the state of New York that used PLIT to support students' academic achievement in math. Due to scheduling limitations, only half of the seventh-grade students used PLIT in addition to the regular math curriculum, which was taught to both the experimental group (i.e., the PLIT users, n = 33) and the control group (n = 33) by the same teacher. Using test scores from the previous year's math scores (2017-2018) as a baseline, this causal-comparative study compared the experimental and control groups' scores after the PLIT intervention. Data were analyzed using ANCOVA with a between-group design in SPSS 26. Results showed a significant difference in students' scores on the New York Math Test in the 2018–2019 school year while controlling the previous year's math scores. PLIT group showed a higher mean score in their New York State Math Exam than the non-PLIT group. The findings can inform education professionals and schools on the possible impacts of PLIT technology in math classes. Implementing the instructional strategies learned from this study could improve students' communication, collaboration, and teamwork skills and enhance teaching and student knowledge in math classrooms, resulting in improved student achievement as a positive social change.

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Dedication

This dissertation is dedicated to my wife, Semanur Yildiz and my son Levent Yildiz. They believed in me; I can do anything that I want to do. I will forever be grateful to them.

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Sincerest regards to my colleague Dr. Yucel Aydos, I will never forget his support. He helped me to stay focused on my research.

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Chapter 1: Introduction to the Study

Math and language skills are a basic measure of student academic achievement in many countries (Funnekotter, 2012). The United States ranked 31st among 35 countries on the Program for International Student Assessment in 2015 (Organization for Economic Cooperation and Development, 2016). This below-average performance was in spite the *United States'* devoting more funding to math education than most other countries (Berrett & Carter, 2018). Despite federal regulations aimed at closing the gaps in math achievement between all subgroups, a recent study showed that the majority of students in the sample failed to qualify as *proficient* in math (Thurlow et al., 2016).

Motivation and engagement are two factors that enhance achievement in math classes and in all subject areas (Rich et al., 2016). Teachers use various techniques to motivate and engage students in class. Traditional techniques, including timed activities, flashcards, and worksheets, have been criticized for their inability to enhance motivation and engagement in math classes (Hawkins et al., 2017). Studies have shown that students exposed to technology in math classes can outperform students who were not (Baker & Cuevas, 2018).

Integrating instructional technology into the curriculum is potentially a way of improving skills. As a result, based on the assumption that technology improves student achievement, schools are increasingly integrating technology into their curricula (Yang et al., 2017); using these technologies to deliver instruction to students who rely on technology in other parts of their lives is an important focus of educators (Dowker et al., 2019). However, research on the effectiveness of various instructional technologies lags behind practice, which means the use of potentially ineffective but costly tools can waste public funds, distract from effective technologies, and lead to a loss of time and energy (Putri, 2016).

One recent tool, Play Lu Interactive Technology (PLIT), is an application that aims to change the traditional school atmosphere into an interactive learning environment through interactive projection and a synchronized sound system (Gagne, 2018; EdCan Network, 2018). PLIT activities are designed to improve student learning by allowing students to respond to questions in each subject area, while enjoying over 30 activities; PLIT can be used to teach various subjects, including math, physical education, and English language arts (personal communication, December 18, 2019) and has been used in schools in more than 20 countries (EdCan Network, 2018). However, research is lacking on the effectiveness of PLIT on student achievement on standardized math tests. This study aimed to fill this gap in the literature by providing empirical data on the effectiveness of PLIT and guidance to researchers and educators in the field.

In this study, I compared the standardized test scores of two groups of seventh-grade students in a K–12 school in New York State. One group of students (n = 33), the experimental group, took part in the PLIT intervention as an extracurricular program; the other group, the control (n = 33) did not take part. In this study, I compared the performance of these two groups on the New York state standardized achievement test in math.

In the first chapter of this dissertation, I provide a statement of the research problem, explain the purpose of the study, introduce the theoretical framework that forms the foundation of the study, describe the nature of the study, discuss positive social change implications, and identify the research questions and hypotheses.

Background

The learning environment is one of the key elements of effective student education. Technology has become an important part of daily life (Yapici & Karakoyun, 2016), and it has become critical for educators to create digital learning environments. As a result, traditional classroom environments have been changed into technology-enriched environments. Technology enables teachers to create interactive learning environments in which teachers and students have rich teaching and learning experiences that traditional learning environments cannot provide (Li et al., 2015).

Research indicates that direct teaching and technology-assisted instruction produce inconsistent results (Nelson et al., 2016). However, despite the number of studies on student engagement and the use of technology in math education, research providing empirical evidence remains lacking (Crawford et al., 2016). The purpose of this study was to fill this gap by examining the use of PLIT and its role in differences in student performance on standardized math test scores.

PLIT (Gagne, 2018) is an interactive instructional technology tool that uses light, sound, and images to engage students. PLIT creates an environment like that of a video game, is designed to help students learn in a fun way, and has the potential to increase student engagement in math classes. PLIT receives signals from the real-time behaviors of students and student interactions through 3D cameras mounted on the walls and enables schools to create smart classrooms that can engage students through active play.

In recent years, many educators in several countries, including the United States and Canada, have adopted PLIT to enhance teaching and student learning (Gagne, 2018). PLIT can be used to engage students in learning math, English language arts, physical education, and social studies (Gilchrist & Gilchrist, 2018). However, although there are many studies on the integration of interactive technology into curricula (Zina & Nadonaly, 2015; Hsu, 2016; Putri, 2016), there is a lack of studies that provide evidence on the usefulness of PLIT.

In many states, including the state of New York, where data collection was conducted, public schools need to show high student achievement growth percentiles (New York State Department of Education [NYDOE], 2018). The principal of the study site, a mid-sized K-12 public school in a city in western New York state, stated that low standardized math test scores were identified as one of the main problems the school was facing (personal communication, December 18, 2019). Also, the public record from the NYDOE (2019) website showed that in the target school, for the 2018–2019 school year, 24% of seventh-grade students scored at Level 1 on the New York State Math Test, which means those students were well below proficient in standards for their grade. Level 3 (out of four levels) is the acceptable threshold level for a student to qualify as meeting state standards. Consequently, the principal decided to purchase PLIT for a group of seventh-grade math classes before the start of the 2018–2019 school year.

Problem Statement

Interactive instructional technologies are promising tools for improving instructional rigor and student engagement (Alzahrani, 2017). Schools that aim to enhance student achievement purchase new technology tools with newer updates (Bakker et al., 2015). However, these tools' effectiveness is not always tested, and some of the interventions are poorly supported by research evidence (Trnova & Trna, 2015). One such popular interactive technology is PLIT. Although the administrators anticipated that PLIT would have a positive effect by enhancing student engagement, and thereby improving students' standardized math test scores, there has been no study to provide empirical evidence in this regard (Beserra et al., 2014; Poly, 2015).

The problem addressed in this study is the lack of evidence for the usefulness of interactive technologies used frequently by students. In this study, I compared the standardized test scores of a group of seventh-grade students who were exposed to PLIT and another group of seventh-grade students who were not exposed to PLIT to determine if test scores significantly improved with the implementation of PLIT during the 2018–2019 school year.

Purpose of the Study

The purpose of this quantitative causal-comparative study was to determine whether standardized mathematics assessment scores differed between two groups of seventh-grade students in a K-12 school in a western city in the state of New York: one group ($n = 33$) was exposed to the use of PLIT software and another ($n = 33$) was not. Although research has shown that integrating technology into instruction can improve student achievement by engaging students in math classrooms (Peterson, 2010), the impact of PLIT has not yet been investigated. I investigated whether PLIT might offer any benefit to math learners, as measured by standardized tests. The results may provide information to schools and education professionals about the possible impacts of integrating PLIT into math classes.

Research Question and Hypotheses

In this study, I compared the standardized test scores of two group of students. The experimental group (n = 33) took part in the PLIT intervention, and the other group, the control group (n = 33), did not. The objective was to determine if the test scores significantly improved with the implementation of PLIT. The research question and hypotheses addressed in this study were:

RQ: Is there a difference between the standardized math test scores of seventh-grade students who use PLIT and those who do not use it?

H_0: There is no significant difference between the standardized math test scores of seventh-grade students who have used PLIT and the standardized math test scores of seventh-grade students who have not used PLIT.

H_A: The standardized math test scores of seventh-grade students who have used PLIT were higher, to a statistically significant degree, than those of seventh-grade students who have not used PLIT.

Theoretical Foundation

The theoretical framework for this research study was the engagement theory framework (Kearsley & Shneiderman, 1998), which associates interactive learning environments and student engagement. According to engagement theory, students should be engaged with the integration of meaningful learning activities (Kearsley & Shneiderman, 1998). Engagement theory suggests that students should be engaged in their classes to enhance teaching effectiveness and student learning (Miliszewska & Horwood, 2004).

The engagement theory framework was the best fit for this study, as any incoming instructional technology tools require an understanding of the relationships among the target instructional technology tool, pedagogy, and content. The engagement theory framework was used to establish an appropriate theoretical context for the study and served as a guide for explaining the results. This study contributes to the previous literature in its application of the engagement theory framework to a PLIT-based intervention that aimed to improve standardized test scores in math classes.

Nature of the Study

In this quantitative research study, a causal-comparative study design was used to investigate whether mathematics assessment scores differ between two groups of seventh-grade students in a K-12 school in New York State: one that used PLIT software and one that did not. The causal-comparative study design was the best fit for this study, because it could be used to address the differences between two groups (Curry, 2017). During the 2018–2019 academic year, the target school used PLIT to improve students' math scores. PLIT was used for one group of seventh-grade students whose schedules were available for implementing PLIT. The other group of seventh graders, however, did not use PLIT due to a scheduling conflict. In this study, I compared the standardized math scores from the two groups.

The standardized math test scores for seventh-grade students during the 2017–2018 and 2018–2019 school years were provided by the school. New York State Math

Test data from the seventh-grade 2017–2018 school year were used as a baseline because PLIT had not been implemented yet. The New York State Math Test scores of seventh-grade students from the 2018-2019 school year were used as postintervention data because this academic year involved the integration of PLIT into one of two classrooms. The class of students that received PLIT intervention was the experimental group of the study, while the class of students unexposed to PLIT was the control group.

Definitions

Interactive learning environment: A learning environment that integrates technology into its curriculum and thereby engages students in active learning (Psotka, 2012).

New York State Math Test: A test administered by the New York Department of Education (2008) based on state and national standards and used to measure math achievement among students in New York state public schools.

Standardized test score: The scaled score in mathematics on the New York State Math Test (New York Department of Education, 2008).

Student engagement: The amount of physical and psychological effort a student dedicates to learning (Blömeke & Kaiser, 2015).

Assumptions

I assumed that the math teachers who participated in the study would have sufficient skills to integrate PLIT into the mathematics curriculum during the 2018–2019 school year. The amount of data was enough to substantiate the findings of the study; data sets obtained from the official website of the NYDOE and individual test scores from the target school made it feasible to compare the standardized math scores of the seventh-grade students. The students were not randomly assigned to the experimental and control groups; they were assigned to classes according to their academic level at the beginning of the school year to balance the classes. Therefore, it was also assumed that the students in the experimental and control groups would be comparable in terms of their responsiveness to the intervention. Another assumption was that the New York State Math Test scores from the seventh grade in the 2017–2018 academic year could serve as solid controlling variable to capture students' level of mathematics prior to the intervention. I also assumed that all the teachers integrated PLIT effectively, truthfully, and accurately.

Scope and Delimitations

This study was restricted to a comparison of the standardized test scores of the two groups of seventh-grade students from a K-12 school in New York State. The main delimitation was that the impact of PLIT was not investigated for all grade levels, and the analysis involved only seventh-grade standardized math scores; therefore, the impact of PLIT should be investigated in the future in other disciplines and at different grade levels. The generalizability of the results to the use of PLIT in the curriculums of other disciplines may be limited.

Limitations

There were limitations to this study that I was unable to control. First, I had no control over how the curriculum was designed or how effective it was in preparing the students for the standardized tests. Also, I did not have control over the knowledge that teachers had of PLIT or their skill in using it; however, PLIT games are simple, and the teachers did not need to have advanced skills to use them (Gagne 2018), so this might have had a minor impact or none. In addition, there could have been other factors that affected the group differences in math achievement besides the use of PLIT, which were not observed. In general, the factors noted here were not taken into account.

Significance

There is no empirical evidence on the effectiveness of PLIT for raising standardized math test scores. This research study provides empirical data on whether PLIT is a viable way to increase these test scores, and the results can help teachers, school leaders, and district leadership make informed decisions about whether to use PLIT.

The findings of this study were found to be statistically nonsignificant, as they may enable teachers, school leaders, and district leadership to look closely at whether the use of PLIT is effective in the math curriculum. By providing a basis for informed decision making about the use of PLIT, the study has the potential to produce positive social change for students. Furthermore, implementing the instructional strategies learned from this study could improve students' communication, collaboration, and teamwork skills and could enhance teaching and student knowledge in math classrooms, resulting in improved student achievement as a positive social change. As math assessment scores fail to improve significantly with the use of PLIT, I pointed this out to the target school, so they could look for different options. I also shared my findings with the PLIT designers, so they could improve their software.

Summary

The use of technology is crucial to the success of a school (Voogt & McKenney, 2016) because the integration of appropriate instructional technology is an important factor in preparing students for their future lives. The purpose of this quantitative causal-comparative study was to determine what difference, if any, Play Lu software makes on mathematics assessment scores among seventh-grade students in New York state.

Chapter 2: Literature Review

In this chapter, I examine the available literature and research related to the research question and define the gap in research on PLIT. The main research question guiding this study was: Is there a difference in standardized math test scores between students who have used PLIT and those who have not? Low performance on standardized test scores among New York state public school students has been identified as one of the main problems with math education in the state. I used a quantitative approach with a causal-comparative design, which was the most appropriate design because it is based on existing data, and there was no way to manipulate the independent variable (Creswell, 2012), in this case, the application of PLIT. The dependent variable was the standardized math test scores for seventh-grade students from the 2018–2019 school year. Data from 2017–2018 school year served as a baseline. This chapter will provide information about the literature search strategy, the theoretical foundations of this study, and a review of the literature related to key concepts and variables.

Literature Search Strategy

The following themes are explored in this review of the literature: student engagement, interactive learning environments, digital learning, the history of technology in K–12 education, professional development for teachers, student perceptions of technology, technology in math education, and the limitations of interactive learning environments. To conduct this review, I used the Walden University Library databases (which included SAGE, ERIC, and Education Research Complete), Google Scholar, and various books containing information on the relevant topics. Some of the key search terms were *technology in the math classroom*, *technology integration*, *PLIT*, *positive learning environment, gaming in learning, engagement theory framework, student perception of technology, low standardized test scores, student engagement in math classroom*, and *standardized tests*.

Theoretical Foundation

Engagement theory was used in this study as a framework for analyzing interactive learning environments. Kearsley and Shneiderman, (1998) stated that the main principle of engagement theory is that students become engaged when presented with meaningful learning activities using instructional technology tools. The use of instructional technology can enhance teaching and student learning when it is difficult to do otherwise (Kearsley & Shneiderman, 1998). Engagement theory was useful in this case for analyzing the relationship between the dependent variable of seventh-grade New York State Math Test results and the independent variable of the integration of PLIT.

A positive influence of student engagement on student success has been reported in various studies (Horstmanshof & Zimitat, 2007; Miron & Urschel, 2016; Rosenshine, 2015). Alzahrani (2017) suggested that schools could improve student engagement and success by integrating more promising instructional practices. Koehler and Mishra (2005) stated that technology is a knowledge system that affords opportunities for enhancing teaching and learning. Banas and York (2014) found that technology provided students with authentic learning experiences and improved their engagement and their perception of school subjects. Lewis (2002) underlined the importance of creating interactive learning environments to improve the quality of student-centered learning, which engages students in classes.

Literature Review Related to Key Concepts and Variables

In this section, I introduce the following key concepts and variables: student engagement, interactive learning environments, digital learning, the history of technology in K–12 education, professional development for teachers, student perceptions of technology, technology in math education, and the limitations of interactive learning environments.

Student Engagement

Engaged students seem more motivated than others (Deveci & Karademir, 2019). Taylor and Parsons (2011) identified student achievement on standardized tests as one of the primary focuses of student engagement. Although there are different ways to measure levels of engagement in education, standardized test scores have been used as one of the most common measures (Fredricks, Hofkens, Mortenson, & Scott, 2018).

Barreto, Orey and Vasconcelos (2017) stated that curriculums and activities must include technology to engage students, as today's students have grown up in a technologized world. Research has shown that technology integration has a great potential to improve student engagement and achievement in math classes (Biancarosa, Goode & Schuetz 2018; Asam, Gallegos, Trussell& Zhang, 2015). In this era, teachers are adopting teaching methods that involve technology, and teaching styles have been shown to affect students' engagement in the classroom (Rosenshine, 2015). Integrating digital learning early can improve the quality of education, teachers' professional development, and curriculum design (Darling, Gaudino & Roschelle, 2016). Trnova and Trna (2015) indicated that student engagement has been positively correlated with how effectively teachers integrate technology into their curriculum, and teachers should update their teaching methods to engage students (Otundo & Garn, 2019; Kim, Cozart, Lee & Park, 2015).

Several studies have demonstrated the importance of technology integration into math classes to promote student engagement (Weisel, 2017; Byno, 2014; Maich, Hall, van Rhijin, and Henning, 2017). When teaching mathematical theories and ideas, a digital curriculum provides technology-centered lessons and new and encouraging opportunities for students to become motivated and engaged (Van Horne & Bell, 2017; Munter & Correnti, 2017). Technology integration supports a revolution in learning practices by helping students to reason about mathematical concepts through experiences in engaging environments (Blikstein, Jackiw, Noss, &Roschelle, 2017), and technology enables teachers to create collaborative, active, and engaging learning environments (Miron & Urschel, 2016). Certain factors can have an impact on a teacher's use of technology and student engagement, such as teachers' willingness to use technology effectively.

Interactive Learning Environments

Research shows that schools should transform their classrooms into more engaging, interactive, and rich environments that can prepare students successfully for their futures in the digital age (Fox-Turnbull, 2016). Shroff and Vogel (2009) indicated that students have more intrinsic engagement within interactive learning environments. Psotka (2012) defined an interactive learning environment as a computer-based instructional system that can be applied to informal, business, and education domains. The findings in the literature demonstrate that integrating technology helps teachers to create engaging classroom environments and that technology tools help teachers to create more visual, interactive, and comprehensive learning environments (Turgut, 2011). Moreover, teachers observe more engagement and excitement in the class when using interactive technology. By integrating mobile devices such as computers, Chromebooks, iPads, and smart phones, teachers can design more data-driven instruction (Blömeke & Kaiser 2015). Students are learning more from technology than from regular instruction. Moreover, technology can support the needs of all types of learners, such as auditory learners, visual learners, and kinesthetic learners (Nam, 2017). Interactive learning technologies, by which students can easily watch and listen at the same time, are suitable for auditory and visual learners. Students in general have short attention spans, and interactive technologies help them maintain focus with colorful screens and a variety of music. Interactive smartboards or similar interactive technologies enhance student learning by allowing students to move elements by touch when learning concepts (Tatli, & Kilic, 2016). With PLIT, for example, students can interact by throwing a soft ball at a large screen when they are encouraged by their teacher to go in front of the board; moreover, the application pushes them to think.

The use of interactive learning technology has been increased in schools recently. Adam-Turner (2016) asserted that interactive learning environments are a driving force for student proficiency. Interactive learning environments enable teachers to make connections between pedagogy and content (Donovan, Green, & Hansen, 2011).

Fayombo (2015) reported that integrating technology into the curriculum improves critical-thinking skills, enhances classroom discussions, facilitates group work, and actively engages students in the learning process. Interactive learning environments improve not only student engagement, but also students' problem-solving and critical-learning skills (Mumtaz & Latif, 2017). Ribero (2016) indicated that it is crucial for teachers to create interactive learning environments, as positive engagement thrives when instructional technology is used in math classes. Chen (2010) indicated that creating interactive learning environments has the potential to improve collaboration and communication in the classroom by improving learning time. These environments promote engaged and flexible learning by providing innovative learning methods and technology tools (Huang & Yang, 2015) and empowering students to participate and take control of their learning process (Marton, 2018). Moreover, interactive learning environments engage students and improve their high-order thinking skills (Gütl, Pirker, &Riffnaller-Schiefer, 2014; Su & Cheng, 2015). Consequently, students' relationship with content can go beyond rote memorization and lead to useful, applicable, and permanent learning. In sum, these findings from the literature show that creating interactive learning environments enhances teaching and student learning.

Teacher perception is also another crucial factor for establishing interactive learning environments. Domingo and Gargante (2016) conducted a quantitative research study to analyze data on teachers' perceptions of creating interactive learning environments. The researchers collected data from 102 teachers via a questionnaire and found that teachers believe their students become more engaged and score better on tests in interactive learning environments than in traditional learning environments (Domingo & Gargante, 2016). Ganesh and Middleton (2006) found that using technology in the math classroom enhances communication and learning objectives. Attard (2013) stated that technology motivates students in an innovative way.

Despite the many known positive influences of interactive learning environments on student learning, some challenges and drawbacks have been reported. Some researchers have found that the use of interactive learning environments was ineffective. Grady et al. (2012) created an interactive learning environment in three different schools in a sixth-grade classroom program, which showed no significant achievement improvement over other sixth-grade students. Hickey et al. (2009) found that fifth-grade students who were exposed to a specific math interactive learning environment had lower achievement.

The effectiveness of learning tools is influenced by several factors, such as the interactive learning environment used, who is using it, and for which subjects and age groups it is appropriate. Teachers can modify their instructional methods to accommodate different learning needs, but in an interactive learning environment this might not be easy (Eklund & Sinclair, 2000; Fatah, Sabandar, Suryadi, & Turmudi, 2016). Furthermore, Asrowi and Hanif (2019) found that even though teachers may have access to interactive learning environments, teachers might not know how to use them meaningfully. Steegen et al. (2018) showed that such environments do not improve student learning when teachers fear using them, and Sumarmo et al. (2018) indicated that classroom management issues increase in the presence of interactive learning environments.

Nevertheless, a lack of improvement in student learning through using interactive learning environments does not necessarily mean the tools are ineffective. The tools might be more effective when handled by experienced teachers who can use them and by teachers who can manage their classrooms effectively.

Digital Learning

Technology has a critical influence on society (Ensminger, 2016). The rapid increase in available technology tools has made technology a fixture in the education system (Mueller, Ross, Specht, Willough & Wood, 2008), and many changes have been made in the classroom culture worldwide (Alsubaie & Ashuraidah, 2017). The National Research Council (2000) advised teachers to implement new and engaging teaching strategies, such as integrating technology into the curriculum, to enhance teaching and student learning. According to Mayclin (2016), by 2016, there was a 71% increase in the number of computers in schools, and 95% of schools had computers. Creating technology-based learning environments shifts education from teacher-centered to more student-centered (Noh & Hamza, 2011), and the integration of technology supports teaching and student learning (Chaney, Kaur, & Koval, 2017). Motion-based technology environments have gained attention over the last decade because they provide new ways for teachers to deliver instruction (Ioannou, Kosmas, & Retalis, 2018).

In recent years, the use of technology in classrooms has continued to increase. Digital curriculums are incorporating electronic devices that help struggling learners (Agus, Bardi, Lucangeli Mascia, Penna, & Perrone, 2018), and successful learning with technology motivates students to move from solo construction to co-construction and then to reconstruction (Smith & Shen, 2017). Moreover, teachers are expected to use technology at maximum levels to support 21st century skills (Sancar-Tokmak, Tanriseven &Yuksekyalcin, 2016).

In STEM subjects, digital literacies provide channels for integrating diverse forms of interdisciplinary learning. For good productive interdisciplinary learning, there must be student engagement to enact and develop discipline-general roles (Applebaum, , Gerard, Linn & Vitale 2017). New technology tools used in math classes improve students' understanding and skills. Better scores have been observed in students exposed to digital learning technology (Ketamo & Kiili, 2018).

Every child learns in a different way, and schools need to incorporate a variety of teaching methods to address the needs of students (Jiang, Shen, & Smith, 2019). To address the skills of 21st-century students, digital games offer a form of literacy (Ketamo & Kiili, 2018); digital games and apps have a positive influence on student success. The use of this type of digital learning tool is crucial, as most modern students respond well to digital games. Fortunately, many newly graduated teachers are familiar with these technologies because they have been playing games for entertainment and using social media since they were kids (Giles & Kent, 2016).

In math classes, math games are rapidly becoming a global trend in children's education. In this new era, as teachers have more access to game-based math apps, they try to integrate them into their classrooms to enhance teaching and student learning. There are millions of mathematics apps installed on iTunes and Android phone/tablet platforms that target preschool, elementary, and middle-school-aged students (Baker, Moyer-Packenham, Tucker, Shumway, Jordan, & Gillam, 2018), and more students are becoming involved with games for learning math in the classroom. Digital math games help instructors to make classes more student-centered and to demonstrate the validity of mathematical concepts (Taylor, 2016). However, digital math technology needs to be updated to catch the most recent mathematics concepts (Papadakis, Kalogiannakis, & Zaranis, 2016). Games-based assessment can be used to decrease test anxiety, which has a negative impact on students' test scores, and help students to be more successful (Bakker, Heuvel-Panhuizen, & Robitzsch, 2015). When students become motivated and confident, their ability to do math problems increases (Boyer-Thurgood, Gulkilik, Jordan & Maahs-Fladung, 2016). These findings show that providing game-based assessments can offer a diverse and comprehensive view of learning.

However, although we know that well-designed interactive learning tools work, we do not yet know if PLIT delivers the intended outcomes.

Students' Perceptions of Technology

Motivation is a critical component of student learning and success. To promote motivation, teachers should identify students' needs and address them in the classroom (Shroff & Vogel, 2009), and they should adopt various techniques to spark students' interest to help them acquire the skills, experience, and knowledge they need to solve real-world problems (Pacia, 2014). Student motivation increases when a sense of interest and involvement is promoted through the implementation of differentiated learning (Huang & Wu, 2007). Research demonstrates that student-centered learning activities are more effective than traditional learning methods for motivating students (Chiu & Cheng, 2017; Gibbes, & Kinoshita, Knight, 2017).

Persada, Miraja, and Nadlifatin, (2019) identify the current generation of students as digital natives who expect to use technology in their classes. In this new era, students use technology in almost every part their lives, and they are described as tech savvy; therefore, it is suggested that teachers integrate technology into their curriculums, as students enjoy learning when technology is involved (Trnova, 2015). Several studies have focused on how students use technology in their classes and how they are motivated through its use (Cherner & Smith, 2017; Huang, & Liou, Su, &Yang, 2017; Colwell & Hutchison, 2015). Other studies have shown that teachers' selection of instructional technology may change students' perception of technology (Kalonde & Mousa, 2016); however, the speed of development challenges teachers to identify the most appropriate technology for their classrooms (Khasawneh, 2018).

Technology in Math Education

Mathematics is the foundation of modern life. If students do better in math classes, it appears there is an increased chance of their doing better in their jobs (Zhang, Trussell, Gallegos, & Asam, 2015). Integrating technology into the curriculum can enhance math teaching and learning (Sadik, 2008; Tomlinson, 2014) and improve students' math skills (Hamil,& Sharp, 2018) by making math more accessible (Cozad & Riccomini, 2016) and helping students to focus better. Furthermore, researchers have found that specialized math apps can be utilized to meet the needs of struggling students (Musti-Rao & Plati, 2015; Bay-Williams & Kling, 2015). The most widely used digital tools are computers and tablets. Nevertheless, teachers are always seeking new methods to engage students and identify effective instructional technologies that support teaching and student learning (Xiaoqing, Yuankun, & Xiaofeng, 2013). As noted above, it has been observed that student interest in math improves when digital game-based activities are integrated into math instruction (Beserra, Nussbaum, Zeni, Rodriguez, & Wurman, 2014; Poly, 2015) and used to strengthen math skills; students can have fun while playing games and learn math concepts at the same time.

Technology integration is highly recommended and supported in math classes, as it engages students (Ok & Bryant, 2016). Research indicates that it enables teachers to provide immediate feedback in a motivating environment (Roschelle, Shechtman, Tatar, Hegedus, Hopkins, Empson, & Gallagher, 2010; Kim & Albert, 2015) and improves students' ability to solve mathematical problems quickly and accurately (Binder, 1996). Also, group work activities that allow students to use instructional technology engage them more in math classes (Ozkal, 2019), and allowing them to use mobile devices can enhance their success in the classroom.

Harris and Al-Bataineh (2015) investigated the impacts of one-to one technology integration on student achievement and found that educators who fully integrated one-to-one technology into their teaching were more successful at engaging their students, compared to teachers who did not use the technology. They also found that students with one-to one technology experience demonstrated better achievement than students without it.

Limitations of Interactive Learning Environments

Creating an interactive learning environment comes with various challenges (Harper, 2009). One is that teachers' technology knowledge and skills are vital to integrating technology into the curriculum to build rich environments (Hammonds, Matherson, Wilson, & Wright, 2013). However, despite the variety of technology tools available for teachers, integrating these technologies into the classroom has been a challenge due to a lack of training for teachers on how to implement technologies effectively (Eskil & Balkar, 2010). Teachers still mostly integrate paper-based activities into their classrooms rather than technological game-based activities, as they lack the knowledge and skills to create technology-rich environments (Melero & Hernandez-Leo, 2014). Also, like teachers, students may have issues with the use of digital tools to improve their learning if they are not familiar with how and why they should use them (Shriner, Clark, Nail, Schlee, & Libler, 2010).

Summary and Conclusion

In a new era of accountability, as technology plays an important role in students' lives, interactive technology tools are drawing significant attention to new ways to create effective classroom environments. There is a significant amount of research on the impact of interactive learning, which can provide engagement and flexibility for teachers and students. However, although interactive learning environments may be useful, the applications and modes of delivery are not always equal in all ways; some may work better than others. While there is currently some research related to instructional technology, there is a lack of research on the impacts of particular technologies and applications. Therefore, this study will be designed to help fill the gap in research on the effectiveness of one such tool, PLIT, in particular in regard to math education.

Chapter 3: Research Method

This chapter contains a detailed description of the sample selection and research design processes involved in this study, including data collection, data management, and analysis, followed by validity and reliability considerations. The study was designed to fill the gap in research that exists regarding the use of PLIT technology, investigating whether the standardized New York State Math Test results of seventh-grade students from a K–12 school in New York State have significantly improved with the implementation of the PLIT program. The research question and hypotheses of the study were:

RQ: What is the difference between the standardized math test scores of students who have used Play Lu and students who have not used Play Lu?

H_0: There is no significant difference between the standardized math test scores of seventh-grade students who have used Play Lu and those of seventh-grade students who have not used Play Lu.

H_A: There is a significant difference between the standardized math test scores of seventh-grade students who have used Play Lu and those of seventh -grade students who have not used Play Lu.

In this chapter, I describe the research design and rationale for this study, the methodology, sample selection, procedures for recruitment, participants, means of data collection, use of archival data, instrumentation and operationalization of constructs, data analysis, threats to validity, and ethical considerations.

Research Design and Rationale

In the current study, I used a causal-comparative design to determine what difference, if any, PLIT makes in the mathematics assessment scores of seventh-grade students in a public school in New York State. One group of students, who took part in the PLIT intervention, served as the experimental group, and the other group, who did not take part in the PLIT intervention, was the control group. A causal-comparative study design was appropriate for this study because it can be used to address differences between groups (Rumrill & Schenker, 2004) and students' preintervention performance was not available for a pre–post comparison. I aimed to examine if PLIT made a difference for 33 seventh graders who used Play Lu during the 2018–2019 academic year (the experimental group) compared to 33 seventh graders who did not use PLIT (the control group). The students' math performance was measured by the New York State Math Test scores. The use or non-use of Play Lu technology served as the independent variable, and the scores of the seventh graders who used Play Lu as the dependent variable. As a measure of the students' level of mathematics achievement prior to the intervention, their scores on New York State Math Test scores in 2017–2018 were used as a covariate, and changes in math achievement scores over time between the experimental and control groups were compared through analysis of covariance (ANCOVA).

Methodology

Population Selection

The study population consisted of seventh-grade students from a mid-sized, public K-12 school in a western city in the state of New York. This school was selected, first, because PLIT was purchased by this school, albeit integrated technology was used in other grades in the school as well. Second, the school administration agreed to collaborate on this research study by providing students' standardized test scores on math; moreover, one group of seventh graders in the 2018–2019 school year was not exposed to PLIT in their math classes, while the other group of seventh-grade students was.

Procedures for Recruitment, Participation, and Data Collection

All the data acquired before and after the integration of PLIT, which were used as the pre- and posttest data sets for the analysis, were received from the target school. The standardized math test was administered at the New York state-wide level to all students in the third through eighth grades. In the 2018–2019 school year, the study school decided to expose 33 of 66 seventh-grade students to PLIT during one period a week as part of their math classes. I compared the data set of the standardized New York State Math Test scores of the 33 seventh-grade students who were exposed to Play Lu with the data set of scores of 33 seventh-grade students who were not exposed to PLIT, to determine whether the use of PLIT resulted in any differences. Both groups of students received 10 hours of math instruction: the control group received 10 hours of standard math instruction, whereas the experimental group received 9 hours of standard math instruction and 1 hour of Play Lu integrated math instruction per week.

Using G*Power software, the required sample size for an ANCOVA design—where the standardized math test scores of the same groups of students in the 2017–2018 academic year were used as the covariate and analogous data from 2018–2019 academic year as the dependent variable—was determined based on an effect size of f = .25. I expected the sample size of 66 would not be sufficient based on the a priori power analysis, but due to a lack of alternative data, I proceeded with the analysis. Fortunately, after the final analysis of data was complete, the achieved power was sufficient due to a large effect size (Appendix A). A power of 80% was used to estimate the sample size, which would increase the probability of detecting the effect of PLIT technology on mathematics scores (Schmidt et al., 2018).

Individual test scores were made available through the school's student data resources. These resources are available to any teacher in the school; teachers are able to consult the test record of any student. The main data used from these data resources were the students' New York state math test scores from the 2018–2019 school year (the postintervention scores) and the 2017–2018 school year (the preintervention scores).

Every student in the seventh grade took the New York state math test. Each student needed only a Chromebook, which was provided by the school, a pencil, and scratch paper to complete the test. All students had to take the New York State Math Test on the same designated day. Any student who was absent that day had to take the New York State Math Test upon their return to school. Comparing the scores of the experimental and control groups was used as the measure of whether PLIT as a treatment affected students’ standardized test results.

The data, upon collection, contained neither names nor other information that would identify individual students, and it consisted only of seventh-grade New York Math Test scores. The data were not shared with the researcher or analyzed until the Walden University Institutional Review Board granted permission. Permission to conduct research in the school district was obtained from the district superintendent. The data, once collected, were placed in a secure location on my home office computer, where they will remain for 5 years, after which time the data will be destroyed. My personal computer is secured by a password, and only I have access to the password. The data were moved to SPSS for statistical analyses. To provide anonymity, I assigned a unique identification number to each student and I am the only person who has access to the unique coding system. The names of the target school, administrators, and teachers were not used.

Archival Data

The archived seventh-grade standardized math test scores from the 2018–2019 school year served as the dependent variables in this study, and the 2017–2018 data were used as baseline scores; the use or non-use of PLIT was the independent variable. The principal of the study site stated that none of the seventh-grade students dropped out during the 2018–2019 school year (personal communication, December 18, 2019) and that the seventh-grade classes in the 2018–2019 school year were academically balanced, but for scheduling reasons, only one seventh-grade section was exposed to PLIT during math classes (personal communication, December 18, 2019).

Description of the Participants

The study was conducted with 66 participants (41 *male* students and 25 *female* students) who were seventh-grade students in a public school in a city in the western part of New York state. Thirty-six students were Black/African American (54.5%), 17 were Asian (25.8%), seven were White (10.6%), four were Latinx (6.1%), and two were Native American (3%). Sixty of the students were on free or reduced lunch (90.9%) and six were not (9.1%). Fifty-seven students had no disability (86.4%), five had a learning disability (7.6%), two had other health impairments (3%), one had an emotional disturbance (1.5%), and one had a speech and language impairment. Seven students were English language learners (10.6%); the rest (89.4%) were not.

Instrumentation and Operationalization of Constructs

The New York State Math Test is a standardized assessment given in several subject areas to all seventh-grade students enrolled in New York state schools. Classroom teachers conduct the assessment over a 2-week timeframe. The results are used to determine whether schools are in compliance with federal standards (NYDOE, 2018). To improve the validity of the test, the questions are written by experienced people at the Educational Testing Service. According to the NYDOE (2018), the New York State Math Test is made up of 45–50 questions, and overall student performance is graded on a scale ranging from Level 1 to Level 5. However, the data analysis for the study was based on a standardized score that ranged from 520 to 643. After the test is conducted, committees of content reviewers and expert teachers from the state of New York work together to improve the consistency of the test question assessment. Also, the NYDOE carefully examines all the test items before they are placed on the test. Pearson Psychometrics and ETS collaborate to support the NYDOE (2018).

Data Analysis Plan

I used the New York State Math Test results to conduct an ANCOVA to determine whether there was a change in standardized math test scores with the implementation of PLIT. Students' 2017–2018 scores were used as a covariate, and the 2018–2019 scores served as the dependent variable in comparing the performance between the experimental and control groups. The inclusion of the previous year's math scores as a covariate ensured that any differences in the math scores of the following year between the experimental and control group were not due to students' level of readiness. The individual student data were provided by the school. After obtaining IRB approval, the data were received in the form of a data report that the school receives annually from the NYDOE. The raw performance data were analyzed using descriptive (M, SD, skew, kurtosis) and inferential (F-test) statistics. Data were analyzed in SPSS Version 26. Because this is an ANCOVA study, a few assumptions were tested before the inferential statistics were analyzed. Students' performance on the standardized math test was compared to determine whether the two groups were comparable in math ability. The data were tested for normality, homogeneity of variance, and homogeneity of the slopes. The descriptive statistics were analyzed in terms of the various demographic variables.

Finally, ANCOVA was conducted to test the hypotheses. The significance of the results was calculated in terms of the p-value and the effect size metric of η2.

Threats to Validity

It is a challenge to verify internal validity in causal-comparative study designs, as the independent variables cannot be manipulated; therefore, the importance of external validity increases. In the New York public school where I conducted my research, the teachers were constantly monitored by the curriculum supervisors of the school; however, both the control and experimental groups were taught by the same teacher (NYDOE, 2018).The validity and reliability of this study were maintained through the use of the New York State Math Test scores, which are considered to be accurate and reliable, as the test questions are aligned with State of New York learning standards. The data are valid and reliable, as reported in the latest Standards of Learning document (NYDOE, 2018).

Ethical Procedures

Prior to the gathering of archival data, approval was obtained from the Institutional Review Board of Walden University. Once approval was granted, the archived standardized math test scores of the seventh graders were obtained from the school and analyzed. The scores were identified after matching them, and each score was identified with either the use or non-use of PLIT. All the data used, namely, the individual test scores, were drawn from publicly available archival data. I assigned a unique identification number to each student to protect the students’ privacy rights, as well as those of the school.

In summary, the data for this study contained neither names nor information that would identify individual students and were restricted to the seventh-grade New York Math Test scores. Permission to conduct research in the school district was obtained from the district superintendent. As noted above, the data were placed in a secure location in my home office, where they will be kept for five years, after which time they will be destroyed. My personal computer is secured by a password, and only I have access to the password.

Summary

This chapter describes the research design process for this study, including the data collection and instrumentation, followed by a treatment of validity and ethical issues.

This is a between- and within-group causal-comparative study comparing the math achievement scores of 33 seventh-grade students during the 2018-2019 school year who received PLIT intervention with those of 33 students who did not. Students' pre-intervention scores were used as a baseline for observing changes over time. The data consisted of the 2018-2019 New York State Math Test scores of students in a mid-sized, public, K-12 school in New York State.

Chapter 4: Results

The results section consists of two parts. In the first part, the descriptive statistics for the sample properties and the nature of the data are presented. In the second section, inferential statistics are presented as evidence to support the assumptions behind the selected analytical approach, an ANCOVA. The purpose of this quantitative causal-comparative study was to determine whether the standardized mathematics assessment scores differ between two groups of seventh-grade students in a K–12 school in New York State: one group ($n = 33$) was exposed to the use of PLIT software in the math classroom and another group ($n = 33$) was not. I used individual student test scores that were provided by the school. The archived seventh-grade standardized math test scores from the 2018–2019 school year served as the dependent variables, and 2017–2018 data were used as baseline scores. All the data acquired before and after PLIT integration, which were used as the pre- and posttest data sets for the analysis, were received from the target school. The following research question and hypotheses guided this study:

RQ: Is there a difference in the standardized math test scores of seventh-grade students who have used PLIT and those who have not used it?

H_0: There is no significant difference between the standardized math test scores of seventh-grade students who have used PLIT and those of seventh-grade students who have not used PLIT.

H_A: The standardized math test scores of seventh-grade students who have used PLIT was statistically significantly higher than those of seventh-grade students who have not used PLIT.

Data Collection

In the 2018–2019 school year, the school decided to expose 33 of its 66 seventh-grade students to PLIT during one period a week as part of their math classes. I chose to use the 66 students as the sample for the study to avoid wasting resources looking for a significant difference in means when there was none. Also, the small sample size made it easier to collect and analyze the data. The standardized math test was administered at the New York state-wide level to all students in the third through eighth grades. The school provided the scores, differentiated by gender, race, disability, economic disadvantage, and whether the students were English language learners. The study aimed to test a research question that required a lot of resources, especially in setting up the PLIT technology.

Access to individual test scores was made available through the school's student data resources. These resources are available to any teacher in the school, and they enable teachers to consult the test record of any student. The data for the covariate were the students' New York State Math Test scores from the 2017–2018 school year while the data for the dependent variable were math test scores from the same students in the 2018–2019 school year.

Data were collected and matched to students, but to maintain students' anonymity, I excluded the participants' names and identifying information. The a priori power analysis calculations indicated that 128 participants would be needed to achieve a power of .80. However, the post-hoc power calculation showed that 66 participants was sufficient to achieve .97 power (Appendix B).

Preliminary Analyses

The current study had two continuous variables: the New York State Mathematics Test scores from the 2018–2019 school year and the corresponding scores from 2017–2018. Table 1 provides the descriptive statistics for these two variables.

Table 1

Descriptive Statistics of the Study

	New York state math scores 2018–2019	New York state math scores 2017–2018
Mean	604.71	596.08
Standard deviation	15.573	17.209
Standard error	1.92	2.12
Skewness	0.453	–0.724
Kurtosis	–0.256	1.659
Minimum	575	542
Maximum	639	637

The sample size was 66 students, with 33 serving as the experimental group exposed to PLIT, while the other 33 served as the control group. Table 1 shows a range of 95 points between the highest and lowest scores in 2017–2018, which is higher than the 64 obtained in 2018–2019, indicating there might be outliers in the 2017–2018 cohort. Students who performed higher in 2017–2018 also scored higher on the exam in 2018–2019. Because the scores for both academic years were standardized, a comparison of the two consecutive years was possible. The scores were higher in 2018–2019 than in 2017–2018, $\mu = 604.71$, $p < .001$, and in 2017–2018, $\mu = 596.08$, $p < .001$, and based on a descriptive statistic, the difference between the 2017–2018 and 2018–2019 scores was statistically significant. Therefore, students’ math performance overall increased from 2017–2018 to 2018–2019.

Table 2

Descriptive Statistics for the New York State Math Scores

	N	Min.	Max.	Mean	*SD*
2017–2018 Scores	66	542	637	596.08	17.209
2018–2019 Control group	33	575	631	597.52	12.130
2018–2019 Experimental group	33	584	639	611.91	15.448

Testing Assumptions of Analysis of Covariance

An ANCOVA was conducted to determine whether the PLIT group outperformed the control group in 2018–2019 by using their 2017–2018 scores as a covariate. The 2018–2019 New York State Math test scores used in this study had minimum score of 575 and a maximum score of 639, and ratio level data as shown on Table 2; therefore, this satisfies the assumption of continuous dependent variable. The dependent variable is represented in the mathematics scores as a ratio variable with an absolute zero, thus satisfying the assumption (Frey, 2017).

The second assumption was that the independent variable should consist of two or more categorical groups. In this study, the classes consisted of 66 pupils divided in half, with 33 in the control group and the other 33 in the experimental group, thus satisfying the assumption of the nominal independent variable.

The New York State Public School, where data were collected in this study, 2017–2018 New York State Math test scores has a minimum score of 542 and a maximum score of 637 as a ratio level data as shown on Table 2; therefore, this satisfies the assumption of continuous covariate. It also satisfies the assumption of independence of observation because no students were in more than one group.

Another assumption of covariates should be linearly related to the outcome variable at each level of the independent variable. The experimental group's covariates are linearly related at each level of the independent variable. For the assumption of linearly related, the scatter diagram was examined for each group. Figure 1 shows that scores used in this study were diagonal, and dependent and independent variables are linearly related; therefore, this satisfies the assumption of linearly related.

Figure 1

Linearly Related Scatterplot of 2018–2019 Score by 2017–2018 Score by Group

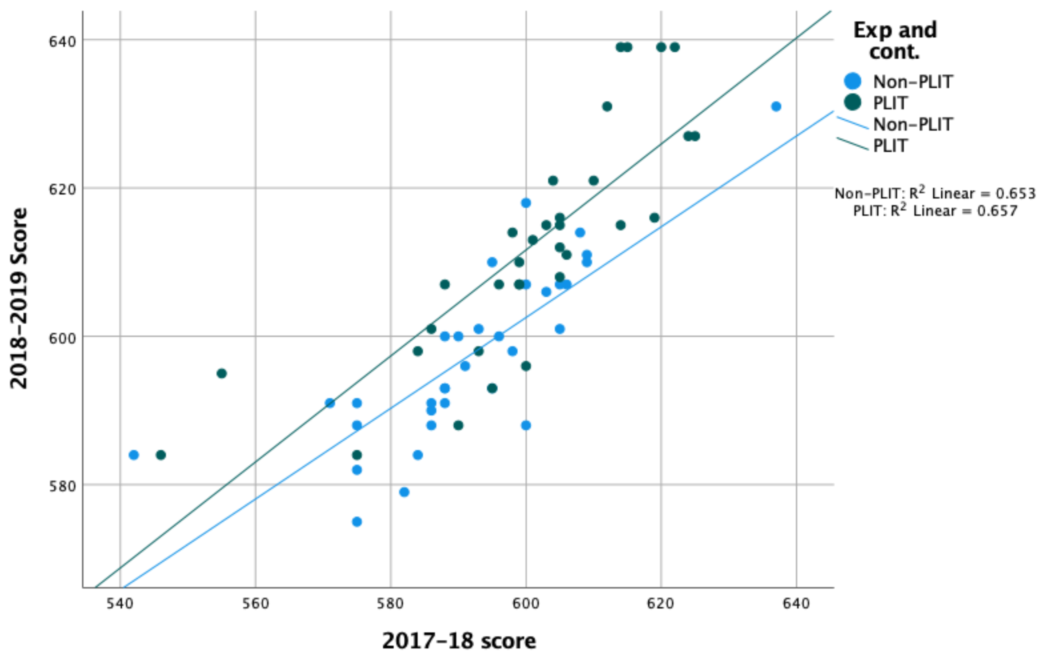


Table 3 shows that regression slopes are homogenous between the groups, as the interaction term (group * @20172018Score) was not statistically significant, F (1, 62) = 47.22, p = .688. Nonstatistically significant interaction between the groups and the covariate is an indication of homogeneity of regression slopes (Stehlik-Barry & Babinec, 2017).

Table 3

Assumption of Homogeneity of Regression Slopes

Dependent variable: 2018–2019 Score

Source	Type III sum of squares	df	Mean square	F	Sig.
Corrected model	11510.223a	3	3836.741	55.928	0
Intercept	2203.988	1	2203.988	32.127	0
Group	34.765	1	34.765	0.507	0.479
@20172018Score	7871.119	1	7871.119	114.736	0
group * @20172018Score	47.22	1	47.22	0.688	0.41
Error	4253.308	62	68.602		
Total	24150429	66			
Corrected total	15763.53	65			

a. R Squared = .730 (Adjusted R Squared = .717)

The final assumption of normally distributed residuals for each category of the predictor variable was tested using the Shapiro-Wilk test and the Kolmogorov-Smirnov test. Both tests showed a significance value for the 2018–2019 academic scores above 0.05, meaning the residuals were normally distributed for each category of the independent variable. Table 4 shows the Shapiro-Wilk test and Kolmogorov-Smirnov test results for the 2018–2019 academic scores.

Table 4

Test of Normality

	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
2018- 2019 Experimental Group	0.096	33	0.187	0.945	33	0.24
2018-2019 Control Group	0.081	33	.201*	0.967	33	0.057

* This is the lower bound of the true significance.

Lilliefors Significance Correction

The assumption of homoscedasticity was tested by creating scatterplots of the standardized residuals of 2017–2018 New York State Math test scores against the predicted values, as shown in Figure 2 and Figure 3. As the samples have the same variance based on the scatterplots, the results satisfied the test for the assumption of homoscedasticity.

Figure 2

2017–2018 Scatterplot of Students with PLIT

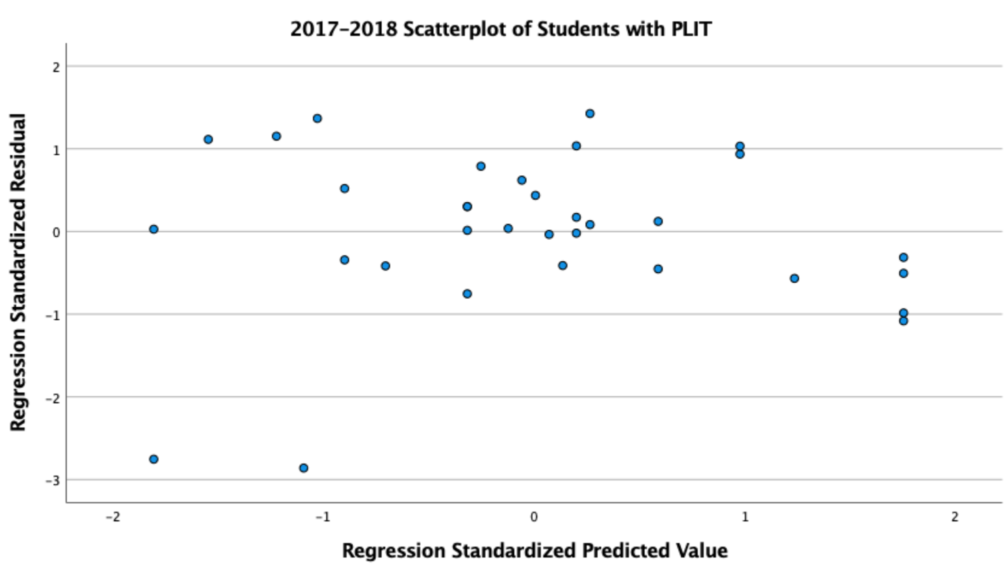
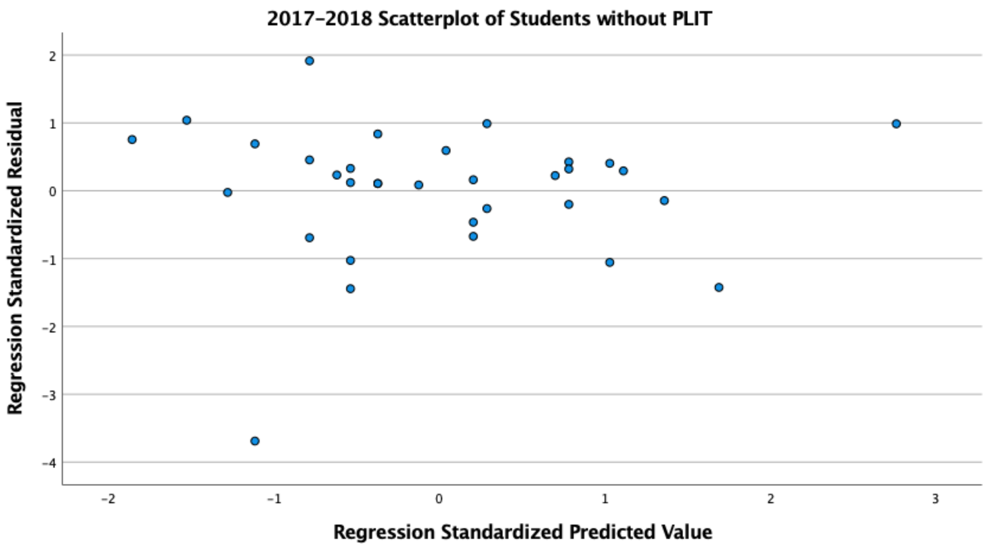


Figure 3

2017–2018 Scatterplot of Students Without PLIT



The homogeneity of variances assumptions was tested using Levene's test for equality of variances (Hollestein, Lo, & Schmidt, 2018), which yielded a p value of 0.220. This was higher than 0.05, meaning that the two groups' variances were equal. The results satisfied the test for homogeneity of variances. Table 5 shows Levene's test results of the homogeneity of group variances.

Table 5

Levene's Test for the Homogeneity of Group Variances

F	df1	df2	Sig.
1.535	1	64	0.22

a. Design: Intercept + @20172018Score+Group

I then tested the data for outliers, which could negatively affect the one-way ANCOVA results and reduce their validity. Figure 4 shows the box plots of 2018-2019 experimental and control groups. Each plot appears relatively symmetrical, with the variances falling between 12.12 and 17.52, an acceptable range; there are no significant outliers that could affect the results.

Figure 4

Box Plots of 2018-2019 Scores

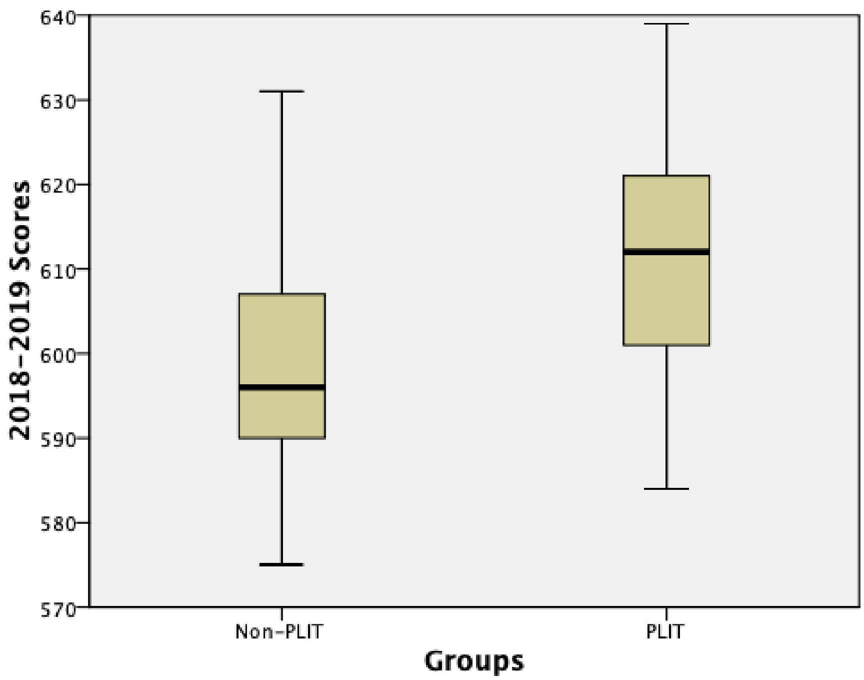


Table 6

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power
Corrected Model	11463.002a	2	5731.501	83.963	0.000	0.727	167.926	1
Intercept	2165.937	1	2165.937	31.73	0.000	0.335	31.73	1
@20172018Score	8044.442	1	8044.442	117.85	0.000	0.652	117.846	1
Group	1161.252	1	1161.252	17.012	0.000	0.213	17.012	0.982
Error	4300.528	63	68.262					
Total	24150429	66						
Corrected Total	15763.53	65						

a R Squared = .727 (Adjusted R Squared = .719)

The ANCOVA results showed significant difference in means between the 2018-2019 experimental and control groups $F(1, 63) = 17.01$, $p < .001$, $\eta p2 = .213$ (Table 5) This analysis also shows that there is a statistically significant difference between the dependent variable and the 2017-2018 covariate (0.00, $p < .005$, $\eta p2 = .65$ (Table 5) indicating the covariate adjusted the relationship between the 2018-2019 control and experimental groups. In the results, the control and experiment group had a significant difference with a large effect size, therefore, the null hypothesis of this research study is rejected.

Summary

The purpose of this quantitative causal-comparative study was to determine whether standardized mathematics assessment scores differed between two groups of seventh-grade students in a K-12 school in New York State, one with and one without the implementation of PLIT. Students' academic performance was measured using New York State Math Test scores from the 2018-2019 academic year. The data were drawn from archived New York State Math Test scores. Comparing the standardized test scores of these two groups of students provided a means of assessing the effects of PLIT on math achievement.

I conducted the ANCOVA analysis to determine if there was a difference between the group who used PLIT technology one hour per week with regular math instruction and the control group who used traditional teaching methods to learn math. The 2018-2019 New York State Math Test scores acted as the dependent variable while the 2017-2018 math test scores served as the covariate. The mean math scores of the PLIT group were higher than those of the non-PLIT group, and the difference was found to be statistically significant. Therefore, the results supported the research hypothesis that the standardized math test scores of seventh-grade students who have used PLIT are statistically significantly higher than those of seventh-grade students who have not used PLIT.

Chapter 5: Discussion, Conclusions, and Recommendations

The purpose of this quantitative causal-comparative study was to determine whether New York State Math Test scores differed between two groups of seventh-grade students in a K–12 school in New York State. I investigated whether test scores were significantly affected by the implementation of PLIT, by comparing the standardized test scores of a group of seventh-grade students, the experimental group (n = 33), exposed to the PLIT intervention, and a second group of seventh-grade students, the control group (n = 33), that did not take part in PLIT intervention. The research question and hypotheses for this study were:

RQ: Is there a difference in the standardized math test scores of seventh-grade students who have used PLIT and those who have not used it?

H_0: There is no significant difference between the standardized math test scores of seventh-grade students who have used PLIT and those of seventh-grade students who have not used PLIT.

H_A: The standardized math test scores of seventh-grade students who have used PLIT were statistically significantly higher than those of seventh-grade students who have not used PLIT.

Key Findings

Based on a previous study by Fredricks, Hofkens, Mortenson, and Scott (2018), in this study, I used standardized scores to measure students' achievement with new technology. Standardized scores were the most widely used measures of students' educational engagement, making their use in this study compulsory. In general, the students scored higher on the 2018–2019 New York State Math Test than the 2017–2018 cohort.

The ANCOVA results showed a statistically significant difference in means between the 2018–2019 experimental and control groups $F(1, 63) = 17.01$, $p < .005$, $\eta p2 = .213$. There was a statistically significant difference between the dependent variable and the 2017–2018 covariate $F(1, 63) = 117.8$, $p < .005$, $\eta p2 = .65$ indicating the covariate adjusted the relationship between the 2018–2019 control and experimental groups. The PLIT group had higher adjusted math scores than the non-PLIT group, and the difference was statistically significant. Therefore, in this respect, the use of PLIT seemed to make a difference between the PLIT group and non-PLIT group.

Interpretation of the Findings

The test results from this study support the hypothesis that there would be a significant difference between the New York State Math Test scores of seventh-grade students who did and did not use PLIT. As seen, there was a significant difference in means between the 2018–2019 experimental and control groups of $F(1, 63) = 17.01$, $p < .001$, $\eta p2 = .213$. The 2018–2019 PLIT cohort had an average score of 611.91, and the 2018–2019 non-PLIT cohort an average score of 597.52. PLIT could have played a role in improving student math results, showing a difference between the existing groups.

The results aligned somewhat with reported findings in the field in that the implementation of technology in math lessons results in an improvement in student performance (Parsons, & Taylor, 2011; Barreto, Orey, & Vasconcelos, 2017). Schuetz et al. and Zhang et al. (2015), and others, have shown that technology integration has a high potential to improve student engagement and achievement in math classes. Therefore, the results of this study suggest that the use of PLIT increased student engagement and subsequently improved students' math scores. According to Deveci and Karademir (2019), engaged students seemed to be more motivated than others.

Another reason for the higher mean of the PLIT-using group could be the interactive nature of the technology and its ability to engage students and push them to think for themselves. Also, young students have short attention spans, and interactive technologies help them to maintain focus through colorful screens and a variety of music. According to Shroff and Vogel (2009), students who used interactive learning environments and technology had more intrinsic engagement, which allowed teachers to create more visual, interactive, and comprehensive learning environments. Students can learn more from interactive technology than from regular instruction. Moreover, technological tools can be modified to suit all students' needs, such as auditory learners, visual learners, and kinesthetic learners (Nam, 2017). Similarly, unlike regular instruction-led math lessons, which cannot consider all students' needs, PLIT can be modified, leading to more understanding on the students' part and, hence, the higher results.

This study disconfirms previous findings by Grady et al. (2012) and Hickey et al. (2009), who found a lower or no difference between their experimental and control groups. In this study, the PLIT students in the study earned higher scores than the control group; therefore, the technology may have made a difference in student performance.

The difference in means between the existing groups confirms that digital learning technologies such as PLIT can make a difference on student achievement. Digital technology supports teaching and student learning by providing teachers with different ways to deliver instruction and maintain student attention throughout math lessons. Technology can improve students' understanding and skills (Papadakis, Kalogiannakis, & Zaranis, 2016), and in this case is seen in better scores with the use of PLIT.

Theoretical Analysis

Engagement theory is a useful framework for analyzing the interactive learning environment created by PLIT. According to Kearsley and Shneiderman (1998), the main principle of engagement theory is that students become engaged when presented with meaningful learning activities through instructional technology tools. Miliszewska and Horwood (2004) stated that students need to be engaged in their classes to enhance teaching and student learning. This study supports both these claims to the extent that there was a significant improvement in the math scores of the PLIT users. The results also support previous findings that student engagement has a positive influence on student success (Horstmanshof & Zimitat, 2007; Miron & Urschel, 2016; Rosenshine, 2015).

Implementing PLIT technology results showed consistency with engagement theory as PLIT led to students' success in improving their New York State Math Test scores. Implementing PLIT technology created an interactive learning environment that gave students and teachers new opportunities to enhance teaching and learning, addressing the needs of all students. Implementing PLIT technology may have also changed the perception of low-performing students toward math, leading to better results on their New York State Math Test (Lewis, 2002).

Limitations of the Study

This study was affected by numerous limitations that significantly hampered its validity, reliability, and generalizability to more heterogeneous populations. One of the limitations was that the sample was confined to only one school in New York state as PLIT is not used widely and some schools did not want to participate in this study. Furthermore, all the participants were in seventh-grade math classes, which limited the study's generalizability to seventh-grade New York State Math Test. The study sample size of 66 students from two mathematics classes also hindered the study's generalizability and validity. I calculated the achieved power using the effect size f = .52. According to the calculations (see appendix A), the achieved power was .97.

The study focused on group differences in academic achievement on the New York State Math Test. Despite teachers' roles in implementing and using technology, they were not taken into consideration. Including a teacher survey in the study would have provided more information on how the PLIT system was integrated into their regular math lessons. Including a teacher survey would also provide more information on the challenges the teachers faced and their successes in implementing the technology, enabling schools to adjust the use of the technology in the future to avoid problems.

A few variables that could influence student scores on New York Math Test were not examined. These include environmental factors such as family, classroom setting, and math teaching experience. Also, teacher perceptions of technology integration, which may influence math achievement, were not considered.

Recommendations

The study answered its main research question on whether there would be significant differences in the standardized math scores between the PLIT and non-PLIT groups. Also, preferably, future studies in the area should focus on students from multiple schools in different states. This would effectively increase the study's generalizability to more heterogenous student populations outside New York State.

In seeking ways to enhance learning in the school environment, Giles and Kent (2016) considered that any personal characteristic, such as a person's perception of his or her capability to perform effectually, needs to be investigated because it weighs the implementation of instructional technology. Conducting qualitative research should enable the researchers to understand the student's thoughts and opinions concerning the technology (Mercer, Hennessy, & Warwick, 2019). Future studies should also include teachers to discuss how they implemented the PLIT technology since they are the ones who incorporate the technology into their regular teaching routines. Gathering further information from teachers may be vital to revealing challenges and enabling schools to avoid problems. Future studies could track student achievement in other subject courses. Tracking student performance in different courses after PLIT implementation could determine if there is a relationship between course type and academic achievement (Rybak, 2018). Therefore, future studies should focus on tracking student performance to see if the same benefits seen in mathematics lessons can be gotten for easier or more complex types of courses.

In addition, this study involved only one school, which limits the generalizability of the findings. Replication of the study is recommended at multiple school sites to ascertain the influence of PLIT on New York State Math Test scores.

Implications

Congress approved the National Education Technology Plan in December 2015 and legislated educational support in 2016 with Every Student Succeeds Act (ESSA). The plan was to improve Future Ready Learning: Reimagining the Role of Technology in Education (U.S. Department of Education, 2016). The purpose of the National Education Technology Plan was to ensure access to 100% of digital transformational learning experiences.

This study showed statistically significant difference between the math scores of the PLIT and non-PLIT groups. The study's results are consistent with the contention that PLIT may have helped students to improve their understanding of course content, thereby performing better on the state math exam." Continued implementation of PLIT technology could improve student collaboration and teamwork and enhance teacher-student communication in math classrooms, resulting in more significant academic achievement.

The study results support the findings of Darling, Gaudino, and Roschelle (2016), Attard (2018), and Rosenshine (2015) that integrating digital learning in teaching can improve the quality of education, teachers' professional development, and curriculum design. In this new era, teaching styles have been shown to affect students' engagement in the classroom, and teachers need to adopt new teaching methods that involve technology. Trnova and Trna (2015) indicated that teachers should update their teaching methods to engage students, and student engagement has been positively correlated with how effectively teachers integrate technology into their curriculum. A digital curriculum for teaching mathematical theories and ideas provides technology-centered lessons and new opportunities for students to become motivated and engaged (Van Horne & Bell, 2017; Munter & Correnti, 2017). It supports a revolution in learning practices by helping students to reason about mathematical concepts through experiences in engaging environments.

However, before implementation, it would be prudent for the schools to consider other factors that affect PLIT implementation, such as different teaching methods, unequal access to technology, and technology integration policies. It is hoped that the relevant stakeholders would consider incorporating PLIT into the national curriculum. Implementing the instructional strategies learned from this study could improve students' communication, collaboration, and teamwork skills, and enhance teaching and student knowledge in math classrooms, resulting in improved student achievement as a positive social change.

Conclusion

The purpose of this quantitative causal-comparative study was to determine whether standardized mathematics assessment scores differed between two groups of seventh-grade students in a K-12 school in New York State, one that had been exposed to the use of PLIT software and another that had not. Some research has shown a positive correlation between integrating technology into curriculum and student success rates (Adam-Turner, 2016; Barreto, Orey,& Vasconcelos, 2017). The study found statistically significant difference in students' scores on the New York Math Test in the 2018-2019 school year with 0.213 medium effect size. These results lead me to conclude that further research is needed to explore other contextual factors that may affect students' academic performance.

Since there are few studies on the learning benefits of PLIT, this study contributes to the literature on this point. The findings can inform education professionals and schools on the possible impacts of PLIT technology in math classes. The results show that the PLIT group had a higher mean in their New York State Math Exam scores than the non-PLIT group. Given the increased use of technology in academics, teachers should learn how to use technologies like PLIT in other subject areas and implement it in their learning strategies.

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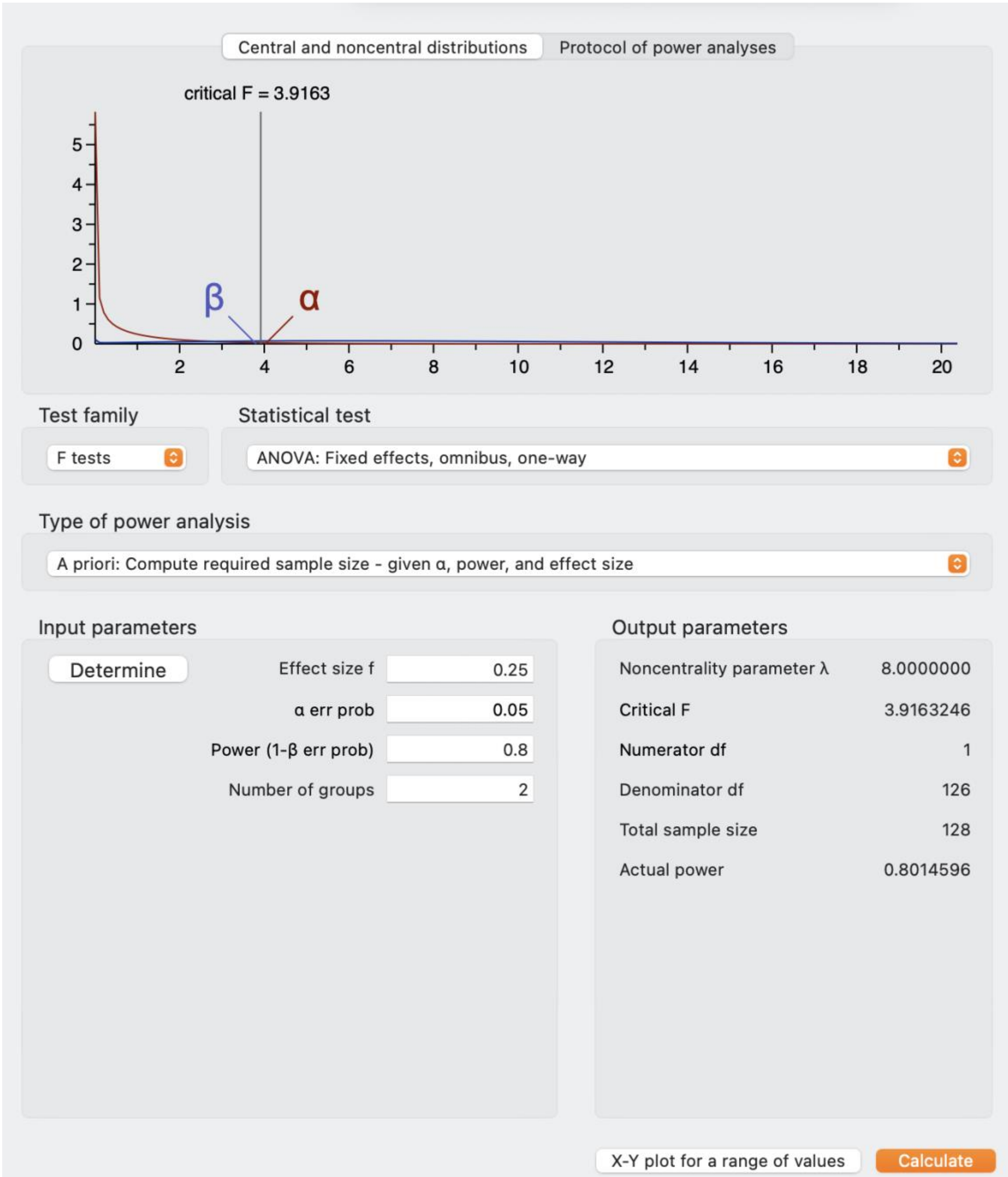
Appendix A: Justification of Sample Size



Appendix B: The Post Hoc Power Analysis