2022

Prodigy Game and Third-Grade Mathematics Achievement in an Urban Setting

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This is to certify that the doctoral study by

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Abstract

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Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Education

Walden University

November 2022

Abstract

Students in Urban District 1 were not meeting grade level learning outcomes in mathematics on state- and district-administered benchmark assessments. The purpose of this study was to determine if including a specific educational video game (EVG), Prodigy, in mathematics instruction with third-grade students would influence students' math achievement as measured by the districts quarterly Star Math benchmark assessments. The research question looked at the difference in students' benchmark assessment scores for mathematics between third-grade users and non-users of the video game learning software Prodigy during the 2017–2018 school year. The use of EVGs as an instructional strategy was examined through the theoretical foundation of the technological pedagogical and content knowledge framework which is used to understand how to effectively integrate technology into the classroom. Using archival scaled scores, this causal–comparative study was conducted to compare achievement scores of students who were in a classroom that used Prodigy and those in a classroom that did not use Prodigy. A total of 2,350 scores were collected in the study. Because data violated the assumptions of an independent t-test, a Mann-Whitney U test was used to analyze the data. The findings showed no statistically significant difference in benchmark assessment scores between Prodigy users and non-users. Further study recommendations include conducting an experimental study to gain a full picture of the potential use of Prodigy in a classroom setting. Potential implications for positive social change from the findings include encouraging that policies and programs on EVG use are drafted to fit the needs and capabilities of students to help learning be fruitful for all learners.

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Dedication

This doctoral study is dedicated to every single person whom I have had the opportunity to learn and grow from in my 20+ years in education. I am starting with my parents for expecting me to be the best I could be. Throughout my elementary, high school, and college education, teachers saw things in me that I never did. Professors recognized my passion for teaching long before I did and encouraged and pushed my thinking. Colleagues made me feel like what I brought to the table was valued and appreciated. Mainly, I dedicate this study to the students I had the pleasure of serving.

Acknowledgments

I want to take this opportunity to thank my husband, Jeffrey Brooks, and three children, Joshua Telker, Katherine Telker, and Victoria Brooks. Many weekends have been consumed by completing this study, which took time away from them, but they understand my drive for those three letters after my name (EdD), even if it became a running joke about being a *forever student*.

I sincerely appreciate the input and support from my dissertation chair, Dr. Heather Pederson. When I stalled in this process, she was always there to give me a gentle boost. Her feedback was spot on, and her encouragement kept me going. Additionally, I would like to thank my methodologist, Dr. Jennifer Lapin. She knew her stuff and was ready to dig into the data with me when I needed help.

This project would be nowhere without the creation of Prodigy Game. While I have never had the privilege of meeting Rohan Mahimker and Alex Peters, I became very enthralled by their creation. I am amazed by their ambition, ingenuity, and passion. I was introduced to Prodigy Game in 2014 and immediately saw the response from my students. Never in my career had I seen students begging to do math. One tends to pay attention when you have students exposed to and answering over 100 math questions in a week. That never happened when just putting a worksheet in front of them or playing with flashcards. Not only were my sixth-graders hooked, but so was I. As an educator, I share Prodigy's vision to help every student in the world love learning math. I hope this research helps other educators invest the time to incorporate Prodigy into their classrooms to ignite the love of learning math for their students.

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Chapter 1: Introduction to the Study

In 2020, educators worldwide pivoted their academic setting from the traditional brick-and-mortar school day to a virtual environment because of the COVID-19 pandemic. Significant consequences were expected for student learning that would disproportionately affect students from disadvantaged backgrounds (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2020). During the response to the global pandemic, educators recognized the need for digital platforms to engage students in learning. This crisis caused educators to rethink mathematics curriculum, practice, and pedagogy. Educational video games (EVGs) are one type of digital platform teachers use to support student learning and engagement. Vetting the hundreds of EVGs available is a huge undertaking. In this study, I focused on a newer EVG for math called Prodigy (2011), which is gaining popularity in schools across the United States because little research has been done on the game's correlation to student achievement. While the foundational pieces of this study began before the COVID-19 pandemic, the need to examine Prodigy as an instructional strategy to increase student achievement in mathematics was relevant to the current state of educational practice worldwide with the shift to virtual and hybrid learning environments.

Providing research-based instructional strategies to educators furthers students' positive social change potential worldwide. In this chapter, I discuss the background related to EVGs. Additionally, the problem and purpose of this study are connected to the key research question. An overview of the theoretical foundation and definitions key to the research are also discussed. The significance of the study includes the impact of social change when considering the long-term solutions or lasting effects of it. The findings of this study have potential implications for positive social change for all mathematics students' educational outcomes and access.

Background

Video games have been a method for engaging and educating audiences for decades. Many children who grew up in the 1970s and 1980s had their first encounter with EVGs while playing *Oregon Trail*. Created in 1971, *Oregon Trail* is the longest-published and most successful EVG of all time (Rankin, 2018). In 1977, the Apple II computer was released and quickly adopted by schools across the United States (O'Regan, 2018). Around 1983, the term *edutainment* was introduced by combining *education* and *entertainment*, and the term is still used to describe educational gaming (Ardianti et al., 2019). This thinking has led to an extension of learning through games on digital platforms. EVGs have become more accepted and are being incorporated into classrooms to improve student learning to positively affect student outcomes (Sánchez-Mena & Martí-Parreño, 2017; see also Bugmann, 2018; Persico et al., 2019).

EVGs are commonly used to promote children's mathematics achievement; however, few rigorous studies have been conducted exploring the effects of video games on skill development and inconsistent results regarding student achievement. Developing mathematic skills in elementary school is essential for continued academic success. Research suggests that early mathematics skill attainment is the most important predictor for achievement in other content areas (Hieftje et al., 2017).

In general, mathematics scores in the United States have not changed in the last 30 years (National Center for Education Statistics [NCES], 2018). EVGs are thought to be effective teaching tools because they increase student engagement, accommodate multiple learning styles, provide practice, and reinforce mastery of skills (Hieftje et al., 2017). The most significant impact may be for students with low skill levels.

Launched in 2011, Prodigy is a free online adaptive learning math video game for students in first through eighth grade. According to the creators of Prodigy, over fifty million students and teachers use the learning platform worldwide. One of the game’s creators, Rohan Mahimker, conducted initial research on the relationship between Prodigy and academic achievement in 2014. More recently, Prodigy was part of a case study by John Hopkins University’s School of Education. Key findings from the case study concluded that the overall relationship is statistically significant but small (Morrison et al., 2020). To improve their academic gain, students would need to spend more time using Prodigy. Because of the John Hopkins case study, Prodigy has been named an Every Student Succeeds Act (ESSA) Tier 3 support. Morrison et al. (2020) suggested the need for further research to examine the full impact on academics.

Problem Statement

Students in the study district (Urban District 1) have not been meeting grade level learning outcomes for math achievement. Both locally and statewide, the math achievement decline was tracked in the trend of standardized test scores in urban math classrooms across the state (Department of Elementary and Secondary Education [DESE], 2020). In 2018, among students in Urban District 1, 17.2% scored in the proficient or advanced categories on the state-mandated standardized test (DESE, 2020). That number remained constant at 17.4% in 2019 (DESE, 2020). Compared to the 2019 state average of 42%, students in Urban District 1 scored 24.6% lower than the state average (DESE, 2020; Urban District 1 administration, personal communication, October 5, 2020).

Additionally, the administration and math curriculum coordinator in Urban District 1 stated that low academic scores in mathematics were a school priority, and they wanted support for intervention in math (math curriculum coordinator, personal communication, October 5, 2020). On a global level, the United States' average math scaled score ranked behind 10 countries in the last *Trends in International Mathematics and Science Study (TIMSS)* as measured every 5 years (NCES, 2018). Declining achievement scores, as measured by state-mandated testing, led teachers to examine supplemental instructional programs and strategies, such as EVGs, to raise student achievement.

In the literature, there is a meaningful gap in practice as teachers deal with the inequities of technology-related resources. While multiple studies demonstrate a positive correlation between the proper and purposeful integration of video-game-based learning on student achievement, little is known about Prodigy specifically (Sørensen & Levinsen, 2015; Sung & Hwang, 2018; Yang, 2017; Yildirim, 2017). Additionally, there is a noted gap in practice regarding the lack of instructional strategies for math instruction using research-based technological tools that increase student-learning outcomes in mathematics. While there has been noteworthy research about the relationship between

EVGs on academic achievement, research has not looked specifically at Prodigy. As an instructional strategy to improve student-learning outcomes in math, some of the district teachers voluntarily implemented the EVG Prodigy. This study will build on the work of previous EVG studies in which researchers looked at academic achievement, but in this study, I focus specifically on Prodigy.

Purpose of the Study

In this quantitative study, the purpose was to determine the effect of Prodigy on third-grade level mathematic outcomes as measured by students' scaled scores on the Star Math assessment in a Midwestern urban school district. Multiple studies have demonstrated a positive correlation between the proper and purposeful integration of video-game-based learning and student achievement (Sørensen, & Levinsen, 2015; Sung & Hwang, 2018; Yang, 2017; Yildirim, 2017). While there has been research about the relationship between EVGs and academic achievement, little is known about how Prodigy influences student achievement in math.

Starting in 2016, multiple teachers in the district chose to use Prodigy as part of their instructional routine, but the relationship between Prodigy and student achievement is unknown. Students had the option to use Prodigy on their own time, but it was not required. In this quantitative study, I compared students' scaled scores on the Star Math assessment in third-grade classrooms where teachers opted to use Prodigy to support math instruction during the 2017 to 2018 school year and students in third-grade classrooms where teachers opted not to use the game in Urban District 1. The variables studied were the students in classrooms whose teachers voluntarily chose to use Prodigy and students in third-grade classrooms whose teachers did not choose to use Prodigy and their grade level achievement as measured by their scaled scores on the Star Math assessments.

I used past school years as a starting point for research. All teachers were required to use the same curriculum, and the student mastery expectation was standard across all classrooms. An expected variance was in teachers' number of years of classroom experience. An independent samples *t*-test was used to correlate the use of versus nonuse of Prodigy and student growth in mathematics achievement as measured by district-administered Star Math assessments. Prodigy's report functionality records the number of questions students accurately answer daily. Further inquiry into Prodigy's impact on student achievement could look at the tipping point for the number of questions answered to the growth relationship. However, new data would need to be collected to address this. Due to COVID-19, that was not an option within Urban District 1.

Research Question and Hypotheses

The purpose of this quantitative study was to determine the effect of Prodigy on third-grade level mathematic outcomes as measured by students' scaled scores on the Star Math assessment in a Midwestern urban school district. The following question was addressed in this study:

RQ: What is the difference in students' benchmark assessment scores for mathematics between third-grade users and nonusers of the video-game learning software Prodigy?

H_0: There is no significant difference in students' benchmark assessment scores between third-grade users and nonusers of Prodigy.

H_1: There is a significant difference in students' benchmark assessment scores between third-grade users and nonusers of Prodigy.

Theoretical Foundation

The technological pedagogical and content knowledge framework (TPACK) combines three main components for teachers' knowledge: content, pedagogy, and technology. The TPACK framework builds from Shulman's (1986, 1987) work around pedagogical content knowledge to connect how knowledgeable a teacher is with their content and the knowledge related to how to teach the content. Additional recognized forms of knowledge include technological pedagogical and content knowledge. Cox and Graham (2009) combined these forms of knowledge into the TPACK framework. Mishra and Koehler introduced the framework in 2006. TPACK is used to look at not only the technology but also how the technology is used. The TPACK framework has been widely discussed for effective teacher integration, but the literature has offered significant implications in practice (Koehler & Mishra, 2009). Some of the work to develop the TPACK framework involved 5 years of conducting experimental design to inform theory and practices. The TPACK framework is a theory used to understand how to effectively integrate technology in the classroom and will be further discussed in Chapter 2. The TPACK framework supports this study because it is a tool to evaluate technological tools, implementation, and practice for classroom teaching in the face of rapidly changing technology.

Nature of the Study

The nature of this study was an experimental causal–comparative or ex post facto research study. Specifically, the study involved a retrospective causal–comparative study design approach. This type of quantitative research is conducted to find relationships between independent and dependent variables after an event has already occurred (Salkind, 2010). A researcher's goal in this type of study is to determine whether the independent variable affected the outcome. The retrospective causal–comparative research design was appropriate for this study due to ethical, time, and cost considerations related to experimental research.

The basic casual–comparative design approach begins with developing research questions and determining independent and dependent variables. Archival data were used to measure third-grade mathematical achievement using the four benchmark assessment scores of third-grade students during the 2017–2018 academic year. Archival data related to voluntary classroom use and student benchmark assessment scores as measured by the Star Math assessments were collected and interpreted. The findings were expected to provide insights into the casual relationships between the variables.

Definitions

Highlighted below are definitions of keywords and terms associated with this study.

Academic achievement (dependent variable): The level of proficiency attained by students in mathematics as measurement by the Star Math benchmarking assessment scores of students.

Adaptive learning software: Prodigy uses algorithms that run in the background to help students learn at their level or within their zone of proximal development, a concept introduced by Vygotsky in 1978. Software of this type is known as *adaptive learning*.

Educational video games (EVGs): computer-based games having a focus on presenting educational material or skills. Holbert and Wilensky (2019) further defined EVGs as *objects-to-think-with* (OTTW).

Prodigy game (independent variable): An online EVG having a specific focus on mathematic skills for first through eighth-grades.

Software: Programs used to operate a computer. For this study, software can refer to programs accessed from CD-ROMS and external disks or web-based platforms.

Star Math/benchmark assessment: A norm-referenced computer-adaptive assessment used to measure academic achievement.

Urban education: NCES (2020) defined a classification system including four categories: city, suburban, town, and rural. In this study, *urban* describes schools within the territory of a city or urban area. Additionally, the population in these areas are 43% minority races/ethnicities instead of 22% in rural areas (U.S. Department of Agriculture, 2018).

Assumptions

This study was conducted under the following assumptions. As the researcher, I assumed the accuracy of data sets collected from the data and research team from the school district. No new data were collected. Prodigy was implemented by classroom teachers voluntarily. Students were not forced to play Prodigy. Teachers were not forced to implement Prodigy in their classrooms. All teachers were required to use the same curriculum. Student mastery expectation was standard across all classrooms. These assumptions were necessary for this study because I did not directly collect data from current student performance. Archival data were used primarily due to COVID-19 pandemic restrictions that did not allow outside individuals to come into the district.

Scope and Delimitations

Urban District 1 is a school district in a Midwest community near a major metropolitan city. There were approximately 36 third-grade teachers in the district. The math curriculum had been used with fidelity for the previous 5 years. As a past employee of the Urban District 1, I had firsthand knowledge that multiple third-grade classrooms were voluntarily using Prodigy as an instructional strategy for mathematics. Additionally, I had firsthand knowledge that the district used Star Math assessments for their quarterly benchmarking system. Star Math had been used in the district for decades. As a norm-referenced test, Star Math had been a consistent measure and predictor of students' academic achievement in mathematics.

When supporting third-grade classrooms in my prior role as an instructional coach within Urban District 1, I observed students highly engaged and motivated to play Prodigy. However, no correlation between gameplay and student achievement had been measured. Because this study was not in place during the actual usage period, I cannot correlate a pivot point for individual students' time spent on Prodigy to their Star Math achievement.

The boundaries of this study include the inability to collect new data or select specific populations outside the archival data available. The population analyzed for this study included third-grade students who took all the benchmark assessments for the 2017–2018 school year. This indicates that these students received a full year's instruction from the math teacher at this school and engaged in mathematical practices. The findings from this study could be generalized to other third-grade students who use Prodigy.

Limitations

The study was limited to the available archival data the district had for the third-grade students using Prodigy during the 2017–2018 academic year. Due to my familiarity with the district as a previous employee, potential bias that could have influenced the study outcomes would occur if any identifiable information were provided along with the data, such as student or teacher names. To address this, the district removed all identifiable information before sending the data to me. This information included name of the student, name of the teacher, and gender. Students and teachers were assigned random numbers and grouped by a teacher-assigned random number. Also, for this reason, the data could not be broken down into the amount of time individual students spent on Prodigy, only that the third-grade students did or did not use Prodigy on a continual basis during the 2017–2018 academic year. Additionally, students' whose data were used for the study cannot be contacted for follow-up questions. The archival data came from students in classrooms where the use of Prodigy was optional for both students and teachers during the 2017–2018 academic year

Significance

The findings of this study will make an original contribution to the field of K–12 educational technology and provide research-based evidence for a specific EVG, Prodigy, to be included or excluded as an instructional strategy in elementary school mathematics classrooms. If this study provides evidence of increased student success, mathematics classrooms worldwide would have an additional research-based approach to support students' academic achievement. The audience for this study includes students, teachers, and school systems. The impact of social change can be measured when considering the long-term solutions or lasting effects of a project (Callahan et al., 2012). The meaningful integration of educational technology has been shown to promote achievement in low-income preschoolers (Griffith et al., 2019).

As a tool of intervention or early engagement, the potential for social change is the increase in student math achievement from an early age that promotes continued learning an academic success for the future. Low mathematic performance in students' academic careers has been linked to high school dropout rates, and this gap is especially prevalent for students from marginalized communities (West et al., 2019). Early mathematics ability has substantial positive associations with adult socioeconomic status (Ritchie & Bates, 2013). Additional findings from the work of Ritchie and Bates (2013) related to mathematics achievement was significantly associated with intelligence scores, academic motivation, and duration of education. The *duration of education* can be transformational for marginalized communities, contributing to the breakdown of cycles of poverty and leading to success for current and future generations.

Summary

EVGs have been studied in business and educational settings. EVGs are specifically designed digital platforms created to address students' academic goals (Bugmann, 2018). Educators are bombarded with new EVGs developed more quickly than they can be evaluated for quality. School districts consider many factors when implementing technology or digital platforms to support learning. One consideration is cost, and many of these platforms come with a high price tag. Prodigy is a unique platform that is free for teachers, students, and parents. Unlike similar platforms, Prodigy offers all its educational content and data reporting features free. This feature led many teachers to use Prodigy as an instructional strategy to support math instruction. Educators must use their instructional time wisely, which is another reason this study was essential. In Chapter 2, I present a review of the literature regarding current trends in the use of EVGs, student engagement related to EVGs, digital strategy's role in math achievement, and teacher perceptions about technology as a tool of instruction. Additionally, Chapter 2 includes a description of the theoretical foundation TPACK and how the theory has been applied in previous research.

Chapter 2: Literature Review

The research problem addressed in this study was that students in the local district have not been meeting district and state grade level expectations for math achievement. Both locally and statewide, the math achievement decline can be tracked in the trend of standardized test scores in urban math classrooms across the state (DESE, 2020). Declining achievement scores, as measured by state-mandated testing, led teachers to examine supplemental instructional programs and strategies, such as EVGs, to raise student achievement.

In urban areas, inequities of resources are exposed when evaluating student access to technology. Multiple studies have demonstrated a positive correlation with the proper and purposeful integration of video-game-based learning on student achievement (Sørensen & Levinsen, 2015; Sung & Hwang, 2018; Yang, 2017; Yildirim, 2017). While there has been noteworthy research about the relationship between EVGs and academic achievement, little is known about how the specific EVG Prodigy influences student achievement in math.

The objective of this quantitative study was to explore the effect of Prodigy on third-grade level mathematics outcomes as measured by students' benchmark assessment scores in an urban school district. Chapter 2 is a wide-ranging literature review that highlights past articles related to the key concepts and variables of the current study. The subsections included in this chapter comprise the literature search plan, theoretical underpinning, review of literature pertinent to main concepts and variables as well as a summary and conclusions.

Literature Search Strategy

The search for peer-reviewed articles published 2017–2021 was conducted using the Walden University online library. The primary databases included Academic Search Complete, ERIC, Sage Journals, ProQuest, and EBSCOhost. Google Scholar was also used to locate open access articles. The following search terms were used: *educational video games, Prodigy game, math achievement, elementary math instructional strategies, digital instructional strategies, student engagement in math, digital natives, teacher perception about technology, 21st century skills,* and *urban education.* Disparities of these terms were adopted to guarantee extensive search results.

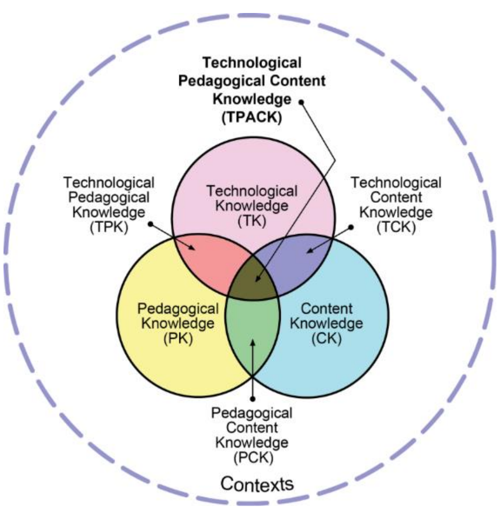
After compiling the initial articles, I looked deeper into the citations of these sources related to EVGs and student achievement in math. From the review of literature, several themes developed, specifically the definition of educational gaming technology, history of EVGs, student perceptions about technology, engagement of students with EVGs, factors that influence students' achievement rates when using EVGs, and the impact of EVG use on academic achievement. The literature review presents a wide-ranging discussion of the highlighted themes.

Theoretical Foundation

The current study was founded on the TPACK framework. The TPACK model combines three main modules for teachers' knowledge: content, pedagogy, and technology (Hsu et al., 2017). The TPACK framework builds on Shulman's (1986, 1987) work around pedagogical content knowledge to connect how knowledgeable a teacher is with their content and the knowledge related to how to teach the content. Additional recognized forms of knowledge include technological, pedagogical, and content knowledge. Cox and Graham (2009) combined these forms of knowledge into the TPACK framework. Mishra and Koehler introduced the framework in 2006. TPACK looks at not only the technology but also how the technology is used. The TPACK model has been extensively discussed for effective teacher integration, but the literature has offered significant implications in practice (Koehler & Mishra, 2009). Some of the work to develop the TPACK framework involved 5 years of experimental design to inform theory and practices. The TPACK framework supports this study because it is a tool to evaluate technological tools and practices for classroom teaching in the face of rapidly changing technology. TPACK is the educational model that supports the integration of games in learning.

Figure 1

Venn Diagram of TPACK



Note. Reproduced from *TPACK Images*, by M. Koehler and P. Mishra, 2012, TPACK.ORG (http://tpack.org). Copyright 2012 by tpack.org. Reprinted with permission.

Figure 1 represents the three focus areas of TPACK. The Venn diagram models the idea that the three focus areas go beyond the knowledge bases in isolation. The emphasis is on the types of knowledge that occur in the connections between content knowledge (CK), pedagogical knowledge (PK), and technological knowledge (TK) (Koehler & Mishra, 2009). Educators are familiar with the intersection of content and pedagogy. In Figure 1, this is modeled in the CK and PK intersection. Pedagogical content knowledge (PCK) is teachers' ability to combine the knowledge of the subject matter with the appropriate practices and methodologies necessary to promote student learning. The TC and CK intersection is technological content knowledge (TCK) and is the "understanding of how technology and content influence and constrain one another" (Koehler & Mishra, 2009, p. 65). Connecting specific technologies appropriate for the needed curricular understanding is reflected in TCK. The third intersection is between TK and PK. Technological pedagogical knowledge (TPK) addresses the range of the technological tools related to developmentally appropriate pedagogical designs and strategies for instruction.

The center intersection of the three focus areas is identified as TPACK. Koehler and Mishra (2009) suggested this is the meaningful and deeply skilled teaching that develops new epistemologies or strengthens prior learning from effective teaching with technology. TPACK goes beyond knowing the focus areas individually into practices that successfully integrate all three (Greene & Jones, 2020). Nonetheless, a critical outlook of instructors' TPACK knowledge growth across settings and the functions tutors are assigned in the class are significant to comprehending the paradigm changes, which inform tutors' practices and training.

The TPACK framework has been adopted widely to achieve various research goals. For instance, Pondee et al. (2021) used TPACK to restructure a preservice science instructor education program with mobile game technology. The education course was administered in two consecutive semesters with an enrollment of 115 learners in the first semester and 94 learners in the second group. A case-oriented TPACK support module was adopted in both groups of students (Pondee et al., 2021). The students were measured in four constructs: technology pedagogical content knowledge (TPCK), TPK, TCK, and TK. The results revealed that the preservice science instructors improved their incremental TPACK after shifting to the use of the case-oriented TPACK support module (Pondee et al., 2021). Based on these findings, Pondee et al. (2021) concluded that the case-oriented TPACK support module was superior to the usual instruction module.

In another study, Hsu et al. (2015) used TPACK to assess the impact of the technology- and pedagogy-centered course framework on enhancing in-service preschool instructors' technological pedagogical content knowledge games (TPACKG). The results indicated that when incorporating the TPACKG model into the preschool setting, instructors who were trained using game knowledge recorded higher proficiencies in PCK and game knowledge compared to those who were not taught using game knowledge (Tseng et al., 2020). Using a comprehensive review of literature, Tseng et al. (2020) found adequate evidence about assessing, exploring, developing, and applying TPACK in learning environments. These studies show that TPACK is a highly utilized framework in the application of technology in education and to understand how to effectively integrate technology into the classroom. The TPACK framework relates to this study because it is a tool to evaluate technological tools, implementation, and practice for classroom teaching in the face of rapidly changing technology.

Literature Review Related to Key Concepts and Variable

Definition of Educational Video Games

There is no established universal definition of an EVG. Huizenga et al. (2017) affirmed that an EVG is a game that has an objective to achieve, rules, activities, outcomes, and competition or conflict. Game activity implies that the game is an activity, an event, or a process that a player is conducting. Game rules are the policies, which are followed while playing the game. An outcome is a numerical score and a specific game action that leads to acquiring or losing points or virtual money. Competition or conflict implies there is some type of challenge—from the game itself or with other players who aim to enhance their distinct scores (Huizenga et al., 2017). Yang (2017) echoed this contemplation and considers EVGs pedagogical games oriented on stipulated learning goals where players aggressively pursue aims through procedures that generate uncertainty and obstacles and produce feedback.

EVGs have been studied in business and educational settings. Daniela (2020) added that a smart EVG method promotes the synergy between pedagogy and technology and uses digital games while learning. These games are specifically designed digital platforms created to address the academic goals of students (Bugmann, 2018). Certain

EVGs, such as Prodigy, focus on learning outcomes for specific content areas such as math, reading, and science.

Researchers commonly describe learning games by their features. Harteveld et al. (2010) posited that learning games should have three design components: validity, learning or pedagogy, and fun. Such games are also referred to as *serious EVGs* because they aim beyond entertainment (Laato et al., 2020). Figure 2 illustrates the concept of a serious EVG. Educational-specific features distinguish serious EVGs from typical games and video games (Laato et al., 2020). Educational games should be fun and at the same time address the aspects of engagement, consequential actions, challenge, uncertainty, coherence, consistency, harmony, and pertinent feedback, both positive and negative (Harteveld et al., 2010).

Gee (2003) reported other aspects of educational games: participant engagement, identity, and value for participants; adaptability for player styles and preferences; contests among participants; manipulation; and transferal of knowledge by participants as well as sufficient and timely feedback to participants. These features echo Bober’s (2020) summary of the features of educational games. In interviews with various experts, Bober (2020) affirmed that learning games should be puzzling, consist of sensory stimuli, deliver a narrative and fantasy, and offer social aspects that encompass collaboration and deliberation or conflict with other people. Bober (2020) further noted that the four tenets of educational games should be facilitated by control, authenticity, creativity, competition, relevance, curiosity, rewards, mystery, feedback, and provides a sense of upgrading. Prodigy is an EVG that meets the features of a serious EVG as described by Laato et al. (2020).

Figure 2

Game Stacked Venn Diagram

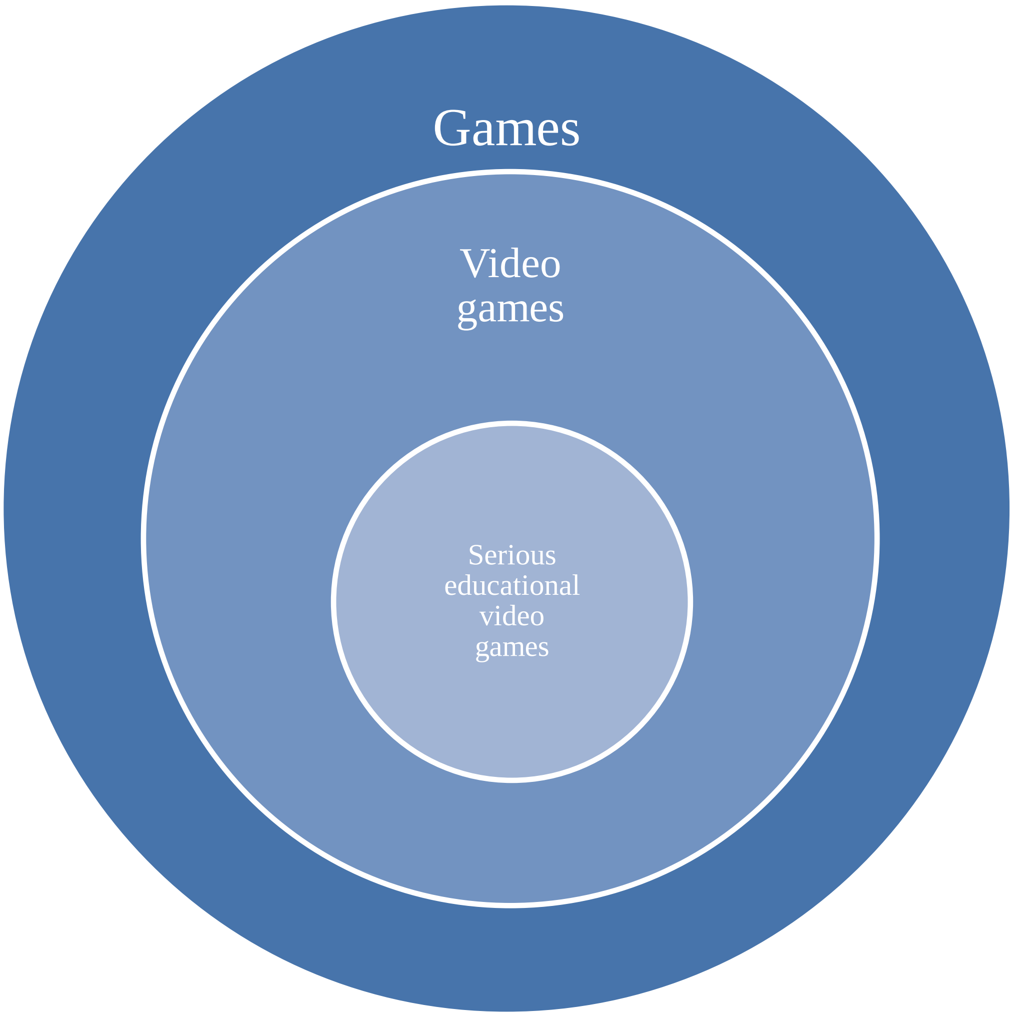


Figure 2 models the subsets of games. Games can be any type of game played by an individual: board games, outside games, or anything is understood as being played for fun. Within that is the subset of video games. Video games are understood to be online or game console system electronic gameplay (Laato et al., 2020). The focus of this study is on serious EVGs that have academic content as the focus of the gameplay.

History of Educational Video Games

Before the 1970s, computers were giant machines that filled a room and were not accessible by the public. After the late 1970s, when personal-sized computers were introduced, education has embraced innovation. Early pioneers recognized the potential to engage the "Atari generation" as a way of encouraging increased enrollment in technical fields (Windnall, 1983). Students anticipated the weekly trip to the computer lab with its rows of Commodore 64 or Apple II computers. They navigated starting up the machines using floppy disks and then switching out the disk to play the 2016 inducted hall of fame game *The Oregon Trail* (2019). As technology continued to advance, generations saw CD-ROM-based games along with the term *Edutainment* being introduced and continues to be used to describe educational video gaming (Edutainment, n.d.). In 1989, the World Wide Web (WWW) was created and then officially launched in 1991 to the public (Nix, 2016). The WWW in turn facilitated new digital inventions such as learning-oriented video games.

The list of popular educational-based game software can be attributed to *The Learning Company*, founded in 1980 (Alexander, 2013). Some of these titles include *Reader Rabbit*, *ClueFinder*, and other titles that engaged students in reading, phonics, math, and problem-solving skills. Other popular academic-focused games include *Math Blaster*, *Mavis Beacon Teaches Typing*, *Number Muncher*, and Where in the World is *Carmen Sandiego* (Hanes & Stone, 2019). Additionally, gaming systems like *Nintendo* have released various educational titles to go along with their consoles like *Brain Age* and *Brain Academy*. Additionally, Sony Play Station released *Little Big Planet*, which introduced the concept of an in-game social community (Fernandez et al., 2019). As the internet became more accessible, we have seen the introduction of web-based games like *Scratch* for coding, *Minecraft* for its educational properties related to 3D design, and *Prodigy Game* for math, among many others.

Student Engagement With Educational Video Games

Piaget (1951) first introduced the concept of children learning through play. This play helps children as they progress through various stages of emotional growth. Participating in more complicated games contributes to cognitive growth (Piaget, 1951). Additionally, the concept of using video games as a means of increasing student engagement came from the innovations being developed (Schindler et al., 2017). Video game use and engagement starts early in growth, and statistics from a U.S. countrywide representative survey show that the intensity of play increases until a steady use trend arises during middle childhood and adolescence ("Common Sense Media," 2017). In this survey, it was found that kids aged between 0 and 8 used digital games for approximately 25 minutes a day ("Common Sense Media," 2017). These findings show that the use and engagement with interactive games start early in one's development.

When software targets students' strengths, weaknesses and strikes a balance for both, it is likely to increase motivation. Engagement with software is key. The quality of the game experience, which includes the game design elements, influences students' intrinsic motivation to learn using the video game (Koehler & Mishra, 2009).

Additionally, studies conducted with students in higher education show that students have disengaged from traditional learning methodologies, and those methods are no longer appealing. In contrast, Martí-Parreño et al. (2018) posit that EVGs can be used to encourage students to engage in content in new ways.

According to Goode and Vasinda (2021), the act of playing video or digital games is a multimodal experience, engrossing the participant in a sensorial encounter in the digital world. Video games can engage the participant because they integrate literacies like character movement, visual text, auditory dialogue, music, sound effects, graphics, and haptic. Because of the sensorial and multimodal state of video games, they have a very high potential to be a vital device for enhancing student engagement during learning as well as to aid them to improve their content knowledge and literacy skills (Goode & Vasinda, 2021). Shu and Liu (2019) extended this topic further by exploring the precise factors of game-based learning which stimulate engagement. To achieve this objective, the researchers assessed twenty empirical studies from peer-reviewed journals which evaluated student engagement. The results depicted that influence the association between game-oriented learning comprised rewards, task features, enjoyment, social association, relatedness, control and autonomy, presence, competence, frequency, self-efficacy, interest, fantasy, and technical issues (Shu & Liu, 2019). These results disclose that the association between the use of game-oriented learning and student engagement is dependent on some factors.

There is noteworthy empirical evidence showing that EVGs play a role in increasing students' engagement. Yu et al. (2020) undertook a study was to appraise various game-centered educational outcomes, encompassing students' behaviors, attitudes, skills, learning efficacy, knowledge, critical thinking abilities, problem-solving capabilities, and learning accomplishments. The results showed that game-centered learning plays a significant role in enhancing learner engagement (Yu et al., 2020). Gamified learning components were further found to enhance student satisfaction in education (Yu et al., 2020). These findings are consistent with a study that was conducted by Schindler et al. (2020) to describe and present a critical literature review of the last five years linked to how web-conferencing software, digital games, social media, wikis, and blogs impact learner engagement. The results from this study depicted that digital games offer the most comprehensive impact across diverse kinds of learner commitment, followed by web-conferencing and Facebook (Schindler et al., 2020). In a similar study, Thongmak (2018) found that game components, directly and indirectly, influenced students' cognitive engagement intention.

Impact of Educational Video Games on Academic Achievement

Academic achievement is described as the learning outcomes which show the extent to which a student has attained their educational objectives (Peng & Kievit, 2020). Typically, academic achievement is measured via continuous assessments or examinations (Peng & Kievit, 2020). There is considerable literature showing that EVGs influence academic achievement among students. Serious EVGs are video games that have an aim beyond entertainment (Laato et al., 2020). The purpose of these "serious" games is to teach something. The effect of EVGs on academic achievement is an area of focus for researchers. Conclusions drawn from this research include the potential of providing high-quality, economical, flexible, convenient, and engaging experiences for students (Yu et al., 2020). Fan et al. (2020) add that computer game-assisted education could generate higher achievement for students as compared to non-computer game-assisted instruction.

As early development of mathematic skills is linked to future academic success, EVGs have been shown to promote academic achievement (Hieftje et al., 2017; Moyer-Packenham et al., 2019). EVGs are thought to be effective tools to support instruction because they have the perceived ability to create personal motivation and satisfaction for students. Additionally, there is the potential to meet the needs of multiple learning styles and skill levels. More than academic skills, well-developed EVGs also have the potential to positively affect desired 21st Century skills and behaviors such as persistence, curiosity, attention, and attitude toward learning (Hieftje et al., 2017). EVGs are oriented to academic achievement as well as to promote attributes that lead to academic achievement.

There is clear empirical evidence showing that EVGs have positive impacts on student achievement. For instance, Persico et al. (2019) researched to assess the link between learning and digital games in the continuum from formal to informal education. Achieving this objective would shed light on the benefits and drawbacks of EVGs in learning as well as gather and comprehend stakeholder suggestions for the key actors in this area of study. The results showed that gameplay impacted players in a very distinct way, and its influence covered a broad range of skills, extending to personality growth (Persico et al., 2019). These results are consistent with a study that was conducted by

Papadakis et al. (2021) to explore the benefits of utilizing tablet-type devices in preschool learning to adopt instructional reform suggestions to apply the Realistic Mathematical Education in kindergarten classes. The results suggested the incorporation of mobile devices and the running of developmentally appropriate applications in kindergarten classes (Papadakis et al., 2021). The researchers determined that properly modeled digital educational practices can be potent educational instruments for effective and efficient learning in kindergarten education (Papadakis et al., 2021). They further established that digital learning tools are efficient for learning at the kindergarten level because they enable kids to take advantage of new educational platforms and effectively achieve new knowledge via activities linked to their immediate real-life situations and interests in learning areas like math.

Studies show that the impact of EVGs extends also to students' attitudes towards lessons. Yildirim (2017) for instance assessed the impacts of gamification-centered instruction practices on learners' performance as well as their attitudes toward the lesson. To achieve this objective, the investigator employed a quantitative study approach and a true experimental framework utilizing pre and posttest intervention and control groups. The research participants comprised ninety-seven sophomores for the department of elementary math education in a state university. Out of these participants, 49 were included in the intervention group while the remaining 48 in the control group. The results revealed that gamification-centered instruction practices had a positive effect on learner performance and learners' attitudes towards lessons (Yildirim, 2017). These results are echoed in a study that was undertaken by Yeşilbağ et al. (2020) to appraise the impacts of pedagogical computer games on the 10th grade learners' attitudes towards the course and academic achievement. The study similarly adopted a quasi-experimental research model with a pre and posttest experiment group and control group. The findings from this study depicted those students in the experimental group had better scores in attitudes towards the course and in their academic achievement (Yeşilbağ et al., 2020). Based on these outcomes, the researchers described gamification or learning processes as the effective incorporation of the gamification model into the education system to enhance learners' inspiration, academic attainment, and outlooks towards lessons.

Most of the established studies on the impact of collaborative digital media on preschoolers, toddlers, and infants have focused on applications and games to reinforce literacy and preliteracy skills (Dore et al., 2018; Kirkorian & Choi, 2017). Dore et al. (2018) conducted a study to compare preschoolers' understanding of an e-book in three scenarios, including independent reading with audio, independent reading without audio, and parent reading. The results depicted that kids understand some content from e-books using audio narration, suggesting that using e-books autonomously can be a significant activity for preliterate kids while their caregivers are occupied (Dore et al., 2018). In a similar study, Kirkorian and Choi (2017) assessed relationships between kids' natural use of interactive and non-interactive media with performance on a screen-centered learning activity. The findings from this study showed that kids' natural encounter with interactive media increased their performance on their screen-centered learning activity (Kirkorian & Choi, 2017). Similarly, Nelson et al. (2016) found out that education technology helps in engaging and inspiring struggling students and that it has the utility for distinguishing and increasing the intensity of intervention and learning. These outcomes led the researchers to conclude that the adoption of interactive media such as apps and games is positively linked to kids' learning performance. There is also a developing literature on the influence of interactive media such as video games and apps on the development of children's skills in science, technology, engineering, and mathematics (STEM).

Impact of Educational Video Games on Academic Achievement in STEM

There is progressing literature on the impact of interactive media such as video games and apps on the development of children's skills in STEM (Griffith et al., 2019; Sheehan et al., 2019). Pila et al. (2019) for instance undertook a study to test children's learning of basic coding skills using a tablet. To achieve this objective, the researchers employed pre and post evaluations and examined kids' conceptual understanding of commands, capability to play Kodable, knowledge of Daisy commands, and appeal of coding applications. Kodable game is played by placing arrows in the appropriate order to remove a character from a maze and Daisy prompts are such as move, grow and jump (Pila et al., 2019). The outcomes showed that the participants enhanced their knowledge of Kodable gameplay and Daisy commands but did not enhance their capacity to verbally explain coding concepts (Pila et al., 2019). The appeal of the games was positively correlated to kids' learning of Daisy prompts, but child sex was unrelated to both Kodable and Daisy's learning results (Pila et al., 2019). These outcomes are consistent with a study that was undertaken by Griffith et al. (2019) to explore the potential of pedagogical applications for digital devices as home-centered learning instruments to facilitate preliteracy and developing mathematics skills among preschool kids. The findings from this study showed that the assessed children recorded noteworthy achievements in preliteracy and emergent mathematics capabilities after using the educational app at home for three months (Griffith et al., 2019). These studies show that kids can learn basic STEM skills through apps and games, particularly those children perceive to be appealing.

In another study, Selvi and Çoşan (2018) explored the impacts of adopting scientific-educational games in tutoring Kingdoms of Living Things on learners' academic achievement and retention of knowledge. To attain this objective, the researchers recruited 68 ninth-grade students and divided them into two groups, the experimental group, and the control group. The findings from a posttest at the end of the study depicted a noteworthy disparity in academic achievement and knowledge retention in favor of the experimental group (Selvi & Çoşan, 2018). Based on these findings, the researchers determined that educational games improve students' academic achievement and are efficient instruments facilitating the retention of new knowledge (Selvi & Çoşan, 2018). These findings are consistent with a study that was undertaken by Ball et al. (2018) to examine the potential of video gameplay to offer a way of enhancing minority learners' comfort with technologies, therefore increasing their positive attitudes towards STEM subjects. The outcomes of this study showed that video game encounters impact STEM attitude through the mediating function of computer self-efficacy and expressive costs (Ball et al., 2018). These outcomes enabled the researchers to conclude that video gameplay can be vital for young digitally divided people because it can offer them positive enactive involvement with technology.

STEM education has been the focus of most researchers because it has become a significant part of school curricula and is vital to filling future occupations (Hawkins et al., 2019). Achieving progress in this field of study has been central as evident in most studies. Researchers together with policymakers have identified the incorporation and adoption of EVGs as one of the approaches to attaining academic progress in STEM education. Burušić et al. (2021) for instance steered an assessment to investigate the link between students' involvement in technology-centered activities such as EVGs at home and STEM school attainment, as well as the moderating role of parental education and gender in this association. To attain this objective, the researchers examined 1,205 learners, 567 of them attending sixth-grade and the other 580 attending fifth-grade in sixteen primary schools. The findings showed no significant connection between student involvement in home-based technology and STEM achievement (Burušić et al., 2021). The home-based technological activities were found to have no value in STEM because they lacked educational-oriented features. Contrary to Burušić et al.'s (2021) findings, Dönmez et al. (2020) determined that the adoption of video games in technology-centered STEM learning promotes learners to join the manufacturing process on a large scale. Based on these results, it is apparent that providing learners with educational content such as game encoding is highly significant rather than providing them with basic technological devices at home.

Most researchers on the impact of gaming on STEM skills create or use specific games in their assessments as opposed to generalizing all EVGs. Bugmann (2018) for instance investigated the association between the knowledge students developed via video games and the typical core skills and knowledge comprised in the French education competency model. After a preliminary student appraisal, the serious game *Food Force* was chosen due to its logical situations and pleasing gaming characteristics. An experimental technique was employed to assess elementary school learners who engaged in a serious video game. The sample comprised 228 learners aged between 8 and 13. The findings depicted that after playing the *Food Force* game, the learners improved in some of the examined areas, including spatial awareness, geometry, scientific and technological culture concerns of human activity, wellbeing, hygiene, comprehending acronyms, and general knowledge (Bugmann, 2018). Similarly, Wommer et al. (2021) created a game, centered on the renowned augmented reality game *Pokémon GO*, referred to as *Insects GO*. The research proposition was that if learners had to struggle while looking for details regarding real insects to play the game, they could develop capabilities, which would potentialize systematic evidence on insect nomenclature and morphology, and ultimately make them more focused on the concerns on the topic. The results depicted playing *Insects GO* was linked to upgrading in topics related to the insect life cycle, taxonomy, and morphology (Wommer et al., 2021). The researchers concluded the use of learning-oriented games such as *Food Force* and *Insects GO* was an ideal way of improving students' learning motivation and achievement.

Mathematics is one of the most assessed STEM topics in the literature on the impacts of interactive media on student achievement. Hieftje et al. (2017) for instance conducted a trial to find using standardized evaluations, the effect of the instructive math tablet-centered video game, *Knowledge Battle* on self-proficiency and mathematics scores. The findings showed enhanced mathematics skills in students who participated in this game (Hieftje et al., 2017). Higher math skills were also reported among participants who had lower pregame as compared to the control group, comprising of students who never played the game (Hieftje et al., 2017). Similarly, Vankúš (2021) examined the impact of the adoption of game-oriented learning on student achievement, intending to analyze its effect on learners' affective domain. To achieve this objective, the researcher adopted a literature review method which yielded a total of fifty-seven articles. Fifty-four percent of the assessed studies considered the affective domain in the determination of game-oriented learning in math education (Vankúš, 2021). Eighty-four percent of the articles reported positive impacts of game-centered learning on students' state of flow, enjoyment, attitudes, engagement, and motivation (Vankúš, 2021). Based on these findings, the researchers concluded that game-based learning enhances students' skills in mathematics.

Factors That Influence Students' Achievement Rates When Using EVGs

While many factors influence students' achievement rates when using EVGs, game design characteristics are a top contributing factor. Research shows that well-designed EVGs that include mathematic principles and rules that are well-integrated with the gameplay can motivate students and result in positive learning outcomes. Moyer-Packenham et al. (2019) conducted a study to explore how design attributes in 12 digital mathematics games impacted students' education. To achieve this objective, the researchers recruited 193 kids in Grades 2 through 6 as study participants. A pre and posttest experiment was undertaken to determine the impact of the games on students' learning. The results depicted substantial achievements for nine out of the twelve games and most students were familiar with the design structures in the games (Moyer-Packenham et al., 2019). The most vital game features were related to game efficiency, progressive levels, focused constraints, information tutorials, and clues, unlimited/multiple attempts, and accuracy feedback (Moyer-Packenham et al., 2019). Morrison echoes these findings et al. (2020) who found out that instructors considered Prodigy features as easy to utilize and valuable to students. Prodigy is the game of concern in the current study.

Contrary, there is empirical evidence that poorly designed EVGs have minimal to no impact on overall student achievement. Fiorella et al. (2019) undertook a study to scrutinize the impacts of adopting a poorly designed narrative computer-centered learning game in a middle-school mathematics class. Gameplay in this study entailed navigating via a computer-generated spaceship and accomplishing expenditures by irregularly participating in learning-by-tutoring practices which entailed assisting an avatar solve mathematics questions. The study participants comprised 48 middle-school learners. A pre and posttest matched-groups study design was employed to investigate the impact of the game. The participants in the game group played the game for 10 hours in 4 days while those in the control group received traditional math guidelines which comprised a matched set of practice mathematics questions. The findings from the analysis showed no significant disparities in learning motivation or outcome between the game group and the control group (Fiorella et al., 2019). These findings are consistent with a study that was conducted by Say and Bağ (2017) to create a computer game for the seventh-grade science class and to examine the impact of this game on learners' aggression and inspiration. The aggression scale and motivation towards science were applied in all study groups three times. The findings showed that the computer game generated a significant difference in motivation but had no impact on student aggression towards science (Say & Bağ, 2017). The researchers realized that the computer game was not oriented to positively impact student aggression (Say & Bağ, 2017). Based on these findings, the researchers concluded that it is essential for a designer to establish EVGs which efficiently balance attributes meant to entertain students and those designed to facilitate learning.

The augmented reality (AR) feature stimulates the effectiveness and efficacy of EVGs. AR is described as an improved version of the actual world which is attained via the adoption of digital visual components, sounds, or other sensory stimuli provided through technology (Farshid et al., 2018). Research shows that AR plays a significant role in enhancing the effectiveness of EVGs. Fan et al. (2020) undertook a methodical literature review on augmented reality (AR) for early language teaching. The findings disclosed five AR core design strategies, which included location-centered features, spatial mappings, gamification, hands-on contact with learning resources, and three-dimensional multimedia content (Fan et al., 2020). Various combinations of teaching strategies and designs appeared to be efficient. Learning enthusiasm was improved by adopting game devices with a discovery approach and educational achievements were improved by utilizing three-dimensional multimedia with advanced organizers and using location-centered content with students' self–exploration (Fan et al., 2020). The results echo a study that was conducted by Taskiran (2018) to examine English as a foreign language students' independent experience concerning the adoption of AR-centered learning resources in their language lessons with a game-oriented technique. The outcomes from this study depicted that most of the learners accepted learning activities in the AR context because they were highly enjoyable and inspirational (Taskiran, 2018). In both studies, future inventors of AR early language apps were recommended to proceed beyond the identified fundamental methods and deliberate on how distinctive paybacks of AR can be implemented to facilitate core undertakings in early language learning.

The educational quality provided by EVGs is another significant topic of concern in the existing literature. Frequently studied elements of EVGs include looking at the value-added by the game, the aesthetic or media features of the game, or the cognitive consequences of playing the game (Firorella et al., 2019). The value-added research approach looks to identify ways to improve the design of the game. Evaluating the media features of the game involves comparing the effectiveness of the game to other presentation modes for the content (Firorella et al., 2019). When combining educational content into mathematic EVGs, studies have consistently found that the learning content must be intrinsically linked to gameplay, proposing challenges, which require the use of mathematical thinking (Laato et al., 2020). Researchers acknowledge that the exponential creation of EVGs on the market has made it difficult to determine the efficacy of these games with the wide variety of products and diverse control groups (Yu et al., 2020; Girard et al., 2013). The research also supports academic improvement for concepts of language learning and history but showed inconsistent results with science and math

(Fiorella et al., 2019; Say & Bağ, 2017). However, game design factors have implications for the lack of measured effectiveness related to academic improvement for students.

The literature on mathematics games highlighted two benefits of EVGs, including connecting learning qualities and gameplay as well as a game model which facilitates learners' deliberate practice (Laato et al., 2020). To determine the educational quality in EVGS, Laato et al. (2020) assessed 109 mathematics games, 48 found on iOS App Store and 61 on Google Play Store. The results exhibited that only 12% of the math games comprised content that support students' deliberate practice and that 11% of the games incorporated learning qualities (Laato et al., 2020). The findings also showed that the games targeted mainly children aged between 6 and 12 and the most featured arithmetic subject (Laato et al., 2020). Holbert and Wilensky (2019) similarly examined design elements that promote EVGs as objects of learning that can extend beyond the game. The participants were nine children between the ages of 11–14 who were recruited by word of mouth in a large Midwestern city. Results showed a strong correlation between proper educational game design and participants' understanding of the goal learning content (Holbert & Wilensky, 2019). These findings affirmed that design plays a vital role in determining the overall impact of EVGs on student achievement.

The third element frequently studied is referred to as the cognitive consequences approach. This approach examines the impacts of playing an EVG as likened to not playing the EVG. Fiorella et al. (2019) point out the benefit of the cognitive consequence approach as being a "more practical approach for the implementation of educational games in the classroom." There is noteworthy empirical evidence that EVGs influence student cognition. Thongmak (2018) for instance undertook a study to explore the factors that impact undergraduate learners' cognitive engagement intent. Actions in the preliminary information systems program were used as the gamified contexts. The researcher described a simple procedure, using learner-led actions to employ gamification in learning contexts. The researcher proposed a research framework comprising of game components, attitude towards the program, supposed game usefulness, and cognitive engagement intention. The findings indicated that game components, directly and indirectly, influenced students' cognitive engagement intention (Thongmak, 2018). These findings are echoed in a study that was undertaken by Megagianni and Kakana (2021) to explore the impact of serious educational games on emotional, social, and cognitive development in middle childhood. The results showed the adoption of serious educational games was positively correlated to emotional, social, and cognitive growth in middle childhood (Megagianni and Kakana, 2021). The conclusion in both studies was that the components of the digital game, as well as the usefulness of the game and attitude towards the course, are the determinants in increasing students' cognitive engagement intention to use gamification in learning.

In addition to designs, studies depict that students' attributes and attitudes play a role in determining the impact of EVGs on academic achievement. Martí-Parreño et al. (2018) for instance conducted a study to assess students' features that impact their attitude towards the utilization and adoption of EVGs to develop aptitudes. Specifically, the researchers assessed how four students' features, including perceived self-efficacy, media affinity, perceived confidence, and perceived relevance impact students' view towards the utilization and adoption of EVGs to develop learning capabilities.

To achieve this objective, the researchers adopted the fuzzy-set qualitative comparative analysis (Fs/QCA) approach to scrutinize data collected from a sample of 128 undergraduate learners. The results portrayed that the four characteristics were necessary and adequate conditions for learners' positive attitude towards the utilization of EVGs to develop their learning capabilities (Martí-Parreño et al., 2018). The use of EVGs in the classroom was found to be mean to inspire and engage learners in their learning course (Martí-Parreño et al., 2018).

These results are consistent with a study that was undertaken by Bovermann et al. (2018) to examine the adoption of a Moodle-based gamification concept and diverse variables linked to the use of a mixed-methods research technique. Thirty-two students participated in a survey and eight were interviewed. The findings of this study showed that there was a significant positive relationship between students' self-reported attitudes towards gaming and satisfaction in the use of gaming in their learning courses (Bovermann et al., 2018). Similarly, Sørensen and Levinsen (2015) found out that the association between student-designed learning goals and the different types of formative assessments strongly influenced students' learning as well as their capacity to undertake qualified learning design and assessments on their own. Based on these findings, the researchers determined that students should be willing to engage in the gaming process for them to achieve the benefits of EVGs.

Teachers' Beliefs About Educational Video Games and Pedagogical Understanding

Educators use technology for a variety of reasons from grade reporting, communicating with parents, lesson plans, and other day-to-day tasks. Additionally, educators are using computers to enhance instructional time. As the pool of current classroom teachers contains larger amounts of individuals who are "digital natives," There has begun a shift in using technology in the classroom for academics. National surveys of EVG usage in classrooms reveal 55% of teachers reporting EVG use every week, with 23% reporting that this usage is every day (Moyer-Packenham et al., 2019). Additionally, there is growing interest among educators and strong claims from those on the front lines that EVGs positively impact student learning (Firorella et al., 2019). One claim frequently made by teachers is that the video-gamed-based approaches to learning were significantly more effective than typical instructional methods (Hieftje et al., 2017). Although there are strong claims, the published evidence yields mixed findings. Teachers frequently report a need for a balance of gameplay elements and academic content (Firorella et al., 2019). The gameplay elements are features that are intended to entertain but end up becoming a distraction to learners.

Educators are inundated with multiple math learning apps in the Apple App Store, Google Play store, and online formats. Laato et al. (2020) evaluated 109 games. Of those games, only five were developed alongside educators. The need for educators to have quality information when making decisions and selecting these games as part of their instructional practice is vitally important. The majority of the EVGs that flood the marketplace have a targeted age group of 6–12-year-olds (Laato et al., 2020). Instructors must be adept in the use of EVGs to guide such young individuals. Studies show that some instructors take the initiative to advance their skills in the use of EVGs and related technology. Callaghan et al. (2018) for instance conducted an assessment to understand how instructors utilize professional development resources such as game-based workshops and technology personnel for integration, to explore how instructors incorporate games into their teaching, and to assess how those tutoring activities are linked to learner success. The research data were gathered using a survey and interviews of 863 elementary school instructors with access to professional development resources for adopting a mathematics game mediation. Data on standardized math test scores were also gathered from 10,715 sixth-grade students. The results depicted that few instructors sought professional development aid for the incorporation of EVGs, but many of them anticipated such provision (Callaghan et al., 2018). The findings further showed that instructors' reorganization of the game aims to support lessons and watching game-oriented professional development videos were linked to increased student success in mathematics (Callaghan et al., 2018). With such knowledge and expertise, educators can be able to effectively guide their students on the proper use of EVGs, including toddlers.

Frequent obstacles to technology incorporation fall into external and internal barriers. External factors would include things that are outside of the instructor's power, such as a lack of technological resources. Internal barriers are those things in which teachers can control like their personal attitude towards technology or their perception of their skill level related to technology. Both types of barriers impact the classroom (O'Neal et al., 2017). While barriers exist, a participant in O'Neal et al.'s study (2017) recognized that technology had the potential to enhance learning. However, most of the teachers in the focus groups primarily saw technology as a supplementary tool in education (O'Neal et al., 2017). Similarly, Sánchez-Mena and Martí-Parreño (2017) conducted a wide-ranging review of literature on instructors' acceptance of EVGs. The results disclosed a broad array of drivers and barriers impacting instructors' acceptance of EVGs (Sánchez-Mena & Martí-Parreño, 2017). The factors, drivers, and barriers were training on EVGs, technical and organizational support, past gaming experience as well as individual factors like inventiveness and openness (Sánchez-Mena & Martí-Parreño, 2017). Comprehending these factors is significant in practice because the success of EVGs in schools highly depends on whether the instructors have accepted them or not.

When the conversation with educators shifts to EVGs, so does the acceptance of this tool as an instructional strategy. In these situations, researchers find the individual teacher's openness and innovativeness as a driver or barrier to implementation. Personal tolerance levels related to noise in the classroom and classroom management styles played a role in educator acceptance of EVGs (Sánchez-Mena, & Martí-Parreño, 2017). Overall, educators' beliefs of EVGs impact classroom management, curriculum, and achievement are that they influence teachers' acceptance of EVGs. According to Martín-del-Pozo et al. (2019), educators' attitude towards new tutoring approaches in among the major factors which contribute to their adoption and impact students' inspiration to learn. Enhancing instructors' attitudes toward the use and implementation of EVGs is therefore very crucial.

Empirical evidence gives a clear depiction of teachers' beliefs concerning EVGs and the pedagogical underpinning of technology. Marín-Díaz et al. (2019) undertook a study to appraise how preservice educators designate the significance of EVGs for education in the initial stages. To achieve this objective, the researchers conducted a survey using questionnaires. Preservice instructors of the degree in primary education of the University of Córdoba were part of a quasi-experimental study that used 62 questions 5-point Likert-type scale reflecting on previous experience in the utilization of video games. One hundred and 69 preservice instructors were assessed, 64.9% of them being male students and the remaining 35.1% were female students. The findings showed that the preservice instructors considered that the adoption of EVGs in primary learning can aid improve behaviors, which are divergent to violence (Marín-Díaz et al., 2019). These findings are consistent with a study that was conducted by O'Neal et al. (2017) to assess instructors' beliefs concerning the role technology plays in the learning process in a sample of urban elementary school tutors in the southeastern United States. The results in this study showed that even instructors perceive the value and importance of technology in education and that they need more assistance on the relevant 21st-century components and knowledge to incorporate technology in education effectively (O'Neal et al., 2017). Based on these findings, the researchers concluded that teachers' beliefs and competencies in using technology play a noteworthy role in determining the effectiveness or failure of EVGs.

In another study, Dong and Mertala (2021) assessed to explore and understand instructors' beliefs concerning children's use of home digital technology and related depictions of teachers and parents. The study was grounded on the point that instructors' views concerning kids' adoption of home technology are intertwined with their perceptions regarding parents and their parenting practices. The participants comprised eight decisively chosen Chinese preservice early childhood instructors. The results exhibited that the participants had inflated positive views concerning kids' normal technology proficiency, but they were concerned that parents would subject kids to technology content for lengthy times (Dong & Mertala, 2021). The preservice instructors shared the view that young kids are skillful users of home technologies. For example, one of the participants stated that young kids can access media technologies routinely and utilize them without challenges. Instructors' responsibility was perceived as answerable role models for kids and educational administrators over parents (Dong & Mertala, 2021). Huizenga et al. (2017) similarly assessed the practice-centered views of instructors who adopt digital games, either by creating or playing games in their lessons. The results from this study depicted that educators who utilize games in class observed student engagement with a game as well as cognitive learning outcomes as impacts of the adoption of games in formal educational environments (Huizenga et al., 2017). Some instructors reported the motivational impacts of tutoring using digital games (Huizenga et al., 2017). Based on these studies, educators seem to have a positive view concerning students' use of digital games.

Research reveals a range of factors which impact the acceptance and beliefs of EVGs by instructors. Sánchez-Mena and Martí-Parreño (2017) undertook a wide-ranging review of literature on instructors' acceptance of EVGs. The results disclosed a broad array of drivers and barriers impacting instructors' acceptance of EVGs (Sánchez-Mena & Martí-Parreño, 2017). The factors, drivers, and barriers were training on EVGs, technical and organizational support, past gaming experience as well as individual factors like inventiveness and openness (Sánchez-Mena & Martí-Parreño, 2017). In a similar study, Adukaite et al. (2017) explored the level at which six determinants, including computer anxiety, self-efficacy, challenge, learning opportunity, curriculum fit, and views about playfulness impacted instructors' advocacy to accept a gamified implementation in the school. The findings revealed that curriculum fit, and perceived playfulness had a positive and direct influence on teachers' intention to accept the gamified application (Adukaite et al., 2017). The exogenous constructs of computer anxiety, self-efficacy, learning opportunities, and challenge had an indirect impact on educators' intention to accept the gamified application (Adukaite et al., 2017). The researchers noted that comprehending these factors is also important in practice because the success of EVGs in schools highly depends on whether the instructors have accepted them or not.

Empirical evidence shows that teachers have positive attitudes and beliefs concerning the use of EVGs, but they do not use these games due to various barriers. Alsuhaymi and Alzebidi (2019) employed a qualitative technique to examine educators' views on the use of video game learning and the obstacles toward incorporating these games into their lessons. To achieve this objective, the researchers collected data via face-to-face interviews with 22 Saudi educators. The findings depicted that instructors in Saudi schools hold positive perceptions concerning the implementation of video games in education and they realized the significance of applying new technologies (Alsuhaymi & Alzebidi, 2019). The educators nonetheless reported that do not integrate video games in their teaching due to various obstacles. These obstacles of implementing video games in learning were found to be the lack of video games, which are suited to schools' curricula and peculiarities, low awareness of the importance of video games in education, and lack of facilitating conditions (Alsuhaymi & Alzebidi, 2019). These findings are consistent with a study that was undertaken by Kaimara et al. (2021) to explore the perceptions of preservice educators on the obstacles of implementing EVGs. Various obstacles were found, but the most critical barrier to the implementation of EVGs was the inefficient allocation of accessible monetary resources (Kaimara et al., 2021). In a similar study, Deng et al. (2020) determined that the barriers of implementing gaming in learning were big class size, challenges in assessing learning outcomes as well as problems in balancing learning and fun. Proper and affordable funding from the government can be one way of resolving these obstacles.

Various studies reveal that teachers' experience in using technologies predicts their attitude to and implementation of video games in their teaching. Mutch-Jones et al. (2021) for instance assessed the adoption methods of nine biology instructors utilizing an immersive digital game in their science lessons while focusing on aspects, which contributed to their capability to teach with the game as well as how their enactment of the game impacted their class experience. To achieve this goal, the researchers collected data from teachers through routine feedback and pre and post adoption surveys, an extended interview, and multiple classroom observations. The findings showed that a trend of instructional orchestration arose, signifying co-teaching, a supportive and reciprocal association between the educator and the game (Mutch-Jones et al., 2021). The game informed educators' thinking regarding their genetics curriculum and improved their teaching practice, while tutors leveraged digital instruments to shape learners' gameplay and to improve what the game provided (Mutch-Jones et al., 2021). Bell and Gresalfi (2017) echo these findings because they similarly found out that educators' experience in adopting EVGs contributes to the effective implementation and utilization of these technologies in the classroom. Even though there is noteworthy literature on teachers' attitudes towards the implementation and use of EVGs, there is no existing study that focuses on specific EVGs such as the Prodigy.

Summary and Conclusions

The literature reveals that the advancement of technology in educational settings has placed new expectations on teachers. It is important to understand what recent research shows about teachers' beliefs regarding the role that technology plays in teaching and learning (O'Neal et al., 2017). Even in the middle of a pandemic, it can be argued that the role of technology in 21st-century teaching has yet to be solidified in elementary classrooms. While we observed teachers make the shift from brick-and-mortar classrooms to a virtual environment, the computer was little more than the vehicle in which education was delivered. As a tool of instruction, EVGs have a mixed review when it comes to their effect on academic achievement. While most can agree that EVGs have become more common in today's education, which EVGs and level of effectiveness have shown inconsistent results in research.

The literature review further discloses that overall EVGs have a positive impact on academic/student achievement (Sørensen, & Levinsen, 2015; Sung & Hwang, 2018; Yang, 2017; Yildirim, 2017). The literature has further depicted that the positive impact of EVGs is linked to the proper design of the games (Moyer-Packenham et al., 2019). Based on the existing literature also, teachers have positive views towards the adoption of EVGs (Adukaite et al., 2017; Dong & Mertala, 2021). Most of the established studies on the impact of collaborative digital media on preschoolers, toddlers, and infants have focused on applications and games to reinforce literacy and preliteracy skills (Dore et al., 2018; Kirkorian & Choi, 2017). There is progressing literature on the impact of interactive media such as video games and apps on the development of children's skills in STEM (Griffith et al., 2019; Sheehan et al., 2019). These researchers have focused on specific games such as *Insects GO*, *Food Force*, and Kodable. Nevertheless, while there has been considerable research about the relationship of EVGs on academic achievement, little is known about how *Prodigy Game* influences student achievement in math. This research gap will be addressed in this study, as stipulated in the research questions and purpose statement. The following chapter, Chapter 3 will provide details of the approach on how to address the identified research gap and attain the study purpose.

Chapter 3: Research Method

The purpose of this quantitative study was to determine the effect of Prodigy on third-grade level mathematics outcomes as measured by students' scaled scores on the Star Math assessment in a Midwestern urban school district. In this study, I compared the scores of third-grade students in classrooms where teachers opted to use Prodigy during the 2017–2018 school years to the scores of third-grade students in classrooms where teachers opted not to use the game in Urban District 1. Starting in 2016, multiple teachers in the district chose to use Prodigy as part of their instructional routine, but the relationship between Prodigy and student achievement is unknown. Students had the option to use Prodigy on their own time, but it was not required.

In this chapter, I discuss the research design and rationale in depth. Additionally, I focus on the methodology related to quantitative studies and any threats to validity. Ethical procedures are also presented. Finally, this chapter ends with a summary of the key points of the research methods employed in the study.

Setting

The study was conducted in a Midwest urban school district in which third-grade teachers used Prodigy as part of their classroom instruction during 2017–2018. Archival data were used to measure mathematical achievement scores using students' benchmark assessment scores in third-grade mathematics. All data collection was conducted in my private office through email exchanges and online transfer of deidentified data for this study.

Research Design and Rationale

Quantitative research has a focus on the outcomes. This study was a quasi-experimental causal–comparative or ex post facto research study. Specifically, I used a retrospective causal–comparative study design approach. This type of quantitative research is conducted to find relationships between independent and dependent variables after an event has already occurred (Salkind, 2010). The goal in this type of study is to determine whether the independent variable affected the outcome. The retrospective causal–comparative research design was appropriate for this study due to ethical, time, and cost considerations related to colleting student achievement scores. A quasi-experimental design was deemed appropriate for the study as opposed to a true experimental design because random assignment of students to classrooms that used Prodigy and classrooms that did not use Prodigy was not possible. Additionally, at the time of this study, the data were archival data collected by the school district annually.

The basic causal–comparative design approach begins with the development of the research questions and determining the independent and dependent variables. Archival data included mathematics achievement scores of third-grade students in classrooms during the 2017–2018 academic year as measured by the district's four benchmark assessments. The data collected support answering the research question guiding this study:

RQ: What is the difference in students' benchmark assessment scores for mathematics between third-grade users and non-users of the video-game learning software Prodigy?

An independent samples *t*-test was conducted with the data set to determine if there was a significant difference in the assessment scores for mathematics between the Prodigy users and Prodigy non-users. The findings provided insights into the causal relationships between the variables. The findings could be used to determine whether the use of Prodigy had an effect on the mathematical academic growth of students as measured by the four benchmark mathematical assessment scores of third-grade students during one academic year.

Methodology

This section includes a discussion of the methodological details regarding this study. This information includes details regarding the selection of data and instrumentation. Additionally, archival data collection, operationalization of constructs, and the plan for data analysis are discussed.

Data Selection

This study was conducted using archival data from a Midwest urban school district with voluntary classroom use of Prodigy. Archival data of four benchmark assessment scores in mathematics were collected for a group of students whose classroom did use Prodigy and for a separate group of students whose classroom did not use Prodigy. For this study, all available archival data were included.

To ensure that sufficient samples were gathered for this study, I conducted an a priori power analysis. The power analysis involved factors such as the effect size, power of analysis, type of analysis, and significance level. For this study, a medium effect size of .25, 80% power, independent samples *t*-test with two groups, and a significance of .05

was considered. The result of the power analysis determined that archival data from a minimum of 128 participants was necessary for the study. Therefore, at least 86 complete sets of data were collected in the study.

Archival Data

Archival data were used in the study. The data in this study included the four Star Math assessment scaled scores of third-grade students for the 2017–2018 academic year. Data were collected from a Midwest urban school district. Permission from the assistant superintendent of research and evaluation and the deputy superintendent of instructional services were obtained to gather de-identified data from their archival records. After gaining approval, de-identified data with the necessary variables in the study were sent to me. The data were to include the four benchmark mathematics assessment scores of students for the 2017–2018 academic year. The data also included whether students were from classrooms that used or did not use Prodigy. Moreover, demographic characteristics of students such as gender, race, and socioeconomic status were included to describe the study data. Data were cleaned to prepare for data analyses.

Instrumentation and Operationalization of Constructs

Archival data from school district records were collected in the study. The dependent variable in the study was the benchmarking mathematics assessment scores of third-grade students during the 2017–2018 academic year. The variable was operationalized using continuous interval data. The independent variable in the study was the use of Prodigy in the classroom. A nominal variable was used to represent the use of Prodigy in the classrooms. Students who were in a class that used Prodigy were coded as

1, whereas students who were in a classroom that did not use Prodigy were coded as 0. Demographic characteristics of gender, race, and socioeconomic status were also coded numerically as using nominal variables to prepare for analysis using SPSS v26.0.

Data Analysis Plan

All data were imported to SPSS v26.0 to prepare for analyses. Data were cleaned for missing values. Listwise deletion was used to remove participants with missing values. The use of listwise deletion ensures that a complete set of data were included in the analyses. Demographic characteristics were to be presented using frequencies and percentages to describe the study participants. The number of participants for each independent group was also reported using frequencies and percentages. Measures of central tendencies were used to present the benchmark assessment mathematics scores of third-grade students during the 2017–2018 academic year.

The data were analyzed to determine the relationship of Prodigy on third-grade level mathematic outcomes as measured by students' scaled scores on the Star Math assessment in a Midwestern urban school district. Prior to conducting the inferential statistics, assumptions were tested. The analysis for this study was an independent samples *t*-test. There are four assumptions for the independent samples *t*-test. First, the dependent variables are measured using a continuous scale. Second, the observations are independent of each other; student participants were only categorized as in a classroom that used Prodigy or in a classroom that did not use Prodigy. The third assumption is normality; the dependent variables of benchmark assessment mathematics scores during the 2017–2018 academic year were tested for normality using the Shapiro-Wilk's test.

The fourth assumption is the assumption of homogeneity of variance. The assumption is that variances of all differences among the benchmarking mathematics assessment scores are equal for the two independent groups. Levene's test was used to test for equality of variances. If assumptions were met, independent samples *t*-test were conducted; otherwise, the Mann-Whitney U test was conducted.

The independent samples *t*-test included two independent groups. The independent variable was the category of use of Prodigy. Students were categorized into two groups: those in a classroom that used Prodigy and those who were in a classroom that did not. A significance level of .05 was used for all analyses.

Threats to Validity

There were threats to internal and external validity of this study. Internal validity is the extent to which the findings of the study can establish cause-and-effect relationships between the variables. The quasi-experimental design has limited the study to collecting existing data from the school districts. Therefore, random assignment of student participants to the two independent groups was not possible. The lack of random assignment may pose biases on the result of the study. There may be confounding variables which may not be considered in the study which include existing mathematics performance of third-grade students. Moreover, the timeliness of data, which were from 2017 - 2018, may provide conclusions that are no longer applicable at present. The teachers who handled the class may also be a factor which was not considered in the study.

External validity is the extent to which findings can be generalized to other measures, settings, or groups. For this study, the focus was on a large Midwest urban school district. The findings of the study may not be generalizable to other settings such as rural school districts. The findings of this study may also be limited to using benchmark assessment scores and no other standardized test scores.

Ethical Procedures

In conducting quantitative studies from secondary data sources, there are ethical procedures to be considered. Prior to collecting any data, approval from the Institutional Review Board (IRB) was obtained. The IRB approval number for this study is 02-15-22-09797533. Permission from the school district was obtained from the assistant superintendent of research and evaluation and the deputy superintendent of instructional services to ensure that they agree to provide access to the necessary data for this study. All data collected in the study were de-identified. The data collected only focused on necessary variables to address the research questions posed in the study. No names, personal identification numbers, or any other information that could identify individuals was used to preserve the anonymity of all participants. All data were stored in a password-protected computer only accessible to me. All data will be retained for 5 years after the completion of this doctoral study and will then be destroyed. I agreed to share the findings with the school district and all stakeholders in the study upon request.

Summary

The purpose of this quantitative study was to determine the effect of Prodigy Game on third-grade level mathematic outcomes as measured by students’ scaled scores on the Star Math assessment in a Midwestern urban school district. A quasi-experimental causal-comparative or ex post facto research study using archival data were employed to address the research question in the study. The target population for this study included third-grade students in schools that use Prodigy Game in their classrooms. Specifically, this study was conducted in a large Midwest urban school district wherein voluntary classroom use of the Prodigy Game was implemented. Archival data of benchmark assessment scores in mathematics was collected in the study. Specifically, data from 2017 – 2018 were included in the study. At least 128 participants were included in the study to achieve statistical validity. The data were analyzed using descriptive statistics and independent samples *t*-test. A significance level of .05 was used for all analyses. Chapter 4 will provide details of the data collection analysis and results.

Chapter 4: Results

The purpose of this quantitative study was to determine the effect of Prodigy on third-grade level mathematic outcomes measured by students' scaled scores on the Star Math assessment in a Midwestern urban school district. The following question was addressed in this study:

RQ: What is the difference in district benchmark assessment scores for mathematics between users and non-users of the video-game learning software Prodigy?

H_0: There is no significant difference in students' benchmark assessment scores between users and non-users of Prodigy.

H_1: There is a significant difference in students' benchmark assessment scores between users and non-users of Prodigy.

This chapter includes a discussion of the data collection and analysis procedures conducted in this study. In this chapter, I also present the findings of data analysis and hypothesis testing. At the end of this chapter is a summary of the key findings.

Data Collection

Archival data of Star Math assessment scaled scores of third-grade students for the 2017–2018 academic year were collected for the study. Data were collected from a Midwest urban school district. Permission from the assistant superintendent of research and evaluation and the deputy superintendent of instructional services were obtained to gather de-identified data from their archival records. After gaining approval, de-identified data with the necessary variables in the study were sent to me. The data included three benchmark assessment scores of students for mathematics for the 2017–2028 academic year. The data also included whether the students were from classrooms that used Prodigy or classrooms that did not use Prodigy. Although collection of demographic characteristics was planned initially, no demographic characteristics information was provided in the data set from the school district. Therefore, data were collected only on Star Math scores, classification of students in terms of Prodigy use, and the semester in which the benchmark assessment scores occurred. A total of 2,350 Star Math scaled scores were collected in the study.

Data Analysis

The initial plan to analyze data were through using the independent samples *t*-test. Independent samples *t*-test involves the comparison of the Star Math scaled score between users and non-users of Prodigy. Independent samples *t*-test is appropriate when the focus of the analysis is to compare the mean scores between two independent groups. However, assumptions of the independent samples *t*-test were tested. The violations with the assumptions warranted the need to use a non-parametric test. Therefore, the Mann-Whitney U test was used in the analysis. The Mann-Whitney U test is the non-parametric counterpart of the independent samples *t*-test wherein the focus is to determine whether there is a difference in the mean ranks of the dependent variables of two independent groups. The test compares whether the distribution of the dependent variable is the same for the two groups. If the result of the Mann-Whitney U test is significant, it indicates that there is a significant difference in the dependent variable based on the two independent groups. A significance level of .05 was used for all analyses.

Results

Table 1 presents the frequencies and percentages of Star Math scaled scores of users and non-users of Prodigy. Data were obtained for 1,591 non-users of Prodigy (67.7%) and 759 users of Prodigy (32.3%). Thus, there were more data available for non-users than users.

Table 1

Frequencies and Percentages of Users and Non-Users of Prodigy

		Frequency	Percent
Prodigy	Non-users	1,591	67.7
	Users	759	32.3
	Total	2,350	100.0

Table 2 presents the descriptive statistics of the Star Math scaled scores. The Star Math scaled scores ranged from 149 to 778. The mean score was 513.53 (SD = 102.95). Table 3 presents the descriptive statistics of the Star Math scaled scores of users and non-users of Prodigy. The mean Star Math scaled score of non-users was 513.11 (SD = 101.25). The mean Star Math scaled score of users was 514.42 (SD = 106.50).

Table 2

Descriptive Statistics of Star Math Scaled Scores

	N	Minimum	Maximum	Mean	SD
Star Math	2,350	149.00	778.00	513.53	102.95

Table 3

Descriptive Statistics of Star Math Scaled Scores of Users and Non-Users of Prodigy

		N	Mean	SD	SE Mean
Star Math scaled scores	Non-users	1,591	513.11	101.25	2.54
	Users	759	514.42	106.50	3.87

Prior to conducting the independent samples *t*-test, the assumptions were tested. The assumptions of an independent samples *t*-test include the normality and the homogeneity of variance assumptions. The Levene's test for homogeneity of variance was used to determine whether equal variances can be assumed. Based on the results shown in Table 4, equal variances cannot be assumed (F = 3.872, p = .049).

Table 4

Levene's Test of Star Math Scaled Scores of Users and Non-users of the Prodigy Game

	Levene's test for equality of variances	
	F	Sig.
Star Math scaled scores	3.872	0.049

Another assumption of the independent samples *t*-test is the assumption of normality. Shapiro-Wilk's test was conducted to determine whether the data follow a normal distribution. Based on the findings shown in Table 5, the data for Star Math scaled scores of both non-users and users are not normally distributed. Therefore, the non-parametric counterpart of the independent samples *t*-test called the Mann-Whitney U test was conducted.

Table 5

Shapiro-Wilk's Test for Normality

		Shapiro-Wilk's		
		Statistic	df	Sig.
Star Math scaled scores	Non-users	0.979	1591	0.000
	Users	0.975	759	0.000

Table 6 presents the results of the Mann-Whitney U test. The results of the analysis determined that the mean rank is not significantly different between the two groups (Z = –.786, *p* = .432). Therefore, there is insufficient evidence to reject the null hypothesis stating that there is no significant difference in students' benchmark assessment scores between users and non-users of Prodigy.

Table 6

Mann-Whitney U Test of Star Math Scaled Scores of Users and Non-Users of Prodigy

	N	Mean rank	Sum of ranks	Mann-Whitney U	Z	p
Non-users	1,591	1,167.91	1,858,137.00	591,701	–0.786	0.432
Users	759	1,191.42	904,288.00			
Total	2350					

Summary

The purpose of this quantitative study was to determine the effect of Prodigy Game on third-grade level mathematic outcomes as measured by students' scaled scores on the Star Math assessment in a Midwestern urban school district. A Mann-Whitney U test was conducted to determine whether there is a significant difference in the Star Math scaled scores of users and non-users. The result determined that there is insufficient evidence to reject the null hypothesis which stated that there is no significant difference in students' benchmark assessment scores between users and non-users of Prodigy Game. In Chapter 5, the details regarding the discussion, conclusions, and recommendations will be addressed to provide details for suggested further study.

Chapter 5: Discussion, Conclusions, and Recommendations

The purpose of this quantitative study was to determine the effect of the EVG Prodigy on third-grade level mathematic outcomes measured by students' scaled scores on the Star Math assessment in a Midwestern urban school district. The main research question addressed in this study was: What is the difference in district benchmark assessment scores for mathematics between users and non-users of the video-game learning software Prodigy? The basis for conducting this research was the gap in practice wherein teachers lack instructional strategies for math instruction using research-based technological tools that increase student-learning outcomes in mathematics. Some of the teachers in the district, as an instructional strategy to improve student-learning outcomes in math, voluntarily implemented an EVG called Prodigy in their classrooms. Little is known about how Prodigy influences student achievement in math. Hence, my exploration was focused on the effect of Prodigy on third-grade mathematic outcomes.

In addressing the purpose and research question, I used a quantitative comparative approach. A quantitative study is appropriate when there is a need to establish the significance of relationships or differences between variables (Salkind, 2010). Based on the purpose of the study, the variables were explored to identify any differences in assessment score for mathematics between users and non-users of the video-game learning software Prodigy. Quantitative comparative research was appropriate for this study.

In facilitating a quantitative comparative research design, I used archival data from a Midwest urban school district in which there was voluntary classroom use of

Prodigy. Specifically, three benchmark assessment scores in mathematics were used. I obtained the data from archives of Star Math scores. The data collected for each student included: Star Math scores, classification of students in terms of Prodigy use, and the semester in which the benchmark assessment scores were collected. A total of 2,350 Star Math scaled scores for users and non-users of Prodigy were identified as data points for this study. Data were analyzed using Mann-Whitney U test because there were violations to the assumptions for independent *t*-test. I used a significance level of 0.05 for all analyses. From the Mann-Whitney U test, I found that the mean rank was not significantly different between the two groups ($Z = -0.786$, $p = 0.432$). Therefore, there was insufficient evidence to reject the null hypothesis, which stated there is no significant difference in students' benchmark assessment scores between users and non-users of Prodigy.

Interpretation of the Findings

The results showed insufficient evidence to reject the null hypothesis. Based on the results, it can be claimed there is no significant difference in the benchmark assessment scores between users and non-users of Prodigy. In relation to the TPACK framework, exploring the role of Prodigy in the performance of students is associated with TPK. TPK is the aspect of TPACK that addresses the range of the technological tools related to developmentally appropriate pedagogical designs and strategies for instruction (Cox & Graham, 2009; Koehler & Mishra, 2009). Prodigy is an EVG that falls under TPK. Based on TPACK, learning could be improved with new epistemologies and effective teaching practices that use technology in an appropriate manner (Koehler &

Mishra, 2009). However, the findings of this study could imply that one of the three components of TPACK were not appropriately used in the integration of technology, pedagogy, and content knowledge in using Prodigy as part of teaching mathematics. However, such claim could not be verified in this study because analysis is based on secondary data and the data collected were limited.

At face value, the findings of the study do not align with claims from literature that EVGs, such as Prodigy, are effective in improving student motivation and performance in school (Goode & Vasinda, 2021; Martí-Parreño et al., 2018; Schindler et al., 2020; Yu et al., 2020). Several researchers have claimed that game-based learning enhances engagement and achievement of students in their academics (Thongmak, 2018; Schindler et al., 2020; Yu et al., 2020). Yu et al. (2020) and Thongmak (2018) claimed that game-centered learning enhances student engagement and helps improve satisfaction in education. Schindler et al. (2020) claimed that digital games offer the most comprehensive impact across diverse kinds of learner commitment.

In terms of academic achievement, scholars have also shown the positive influences of EVGs on student academic performance (e.g., grades, exam scores; Pila et al., 2019; Selvi & Çoşan, 2018; Yeşilbağ et al., 2020; Yildirium, 2017). Yildirium (2017) claimed that gamification of learning practices has a positive effect on student performance. In Yeşilbağ et al.'s (2020) comparative study, students in the experimental group who used pedagogical computer games had better scores in academic achievement measures compared to students in the control group. Pila et al. (2019) found that students who used digital games for learning have enhanced STEM skills, especially with programs or apps appealing to children. Similarly, Selvi and Çoşan (2018) found that educational games improve students' academic achievement and are efficient instruments facilitating the retention of new knowledge. Other literature reviewed includes Shu and Liu (2019) summarized the use of games could encourage learning because of the concepts of rewards, task features, enjoyment, social association, relatedness, control and autonomy, presence, competence, frequency, self-efficacy, interest, fantasy, and technical issues. In another study, Ball et al. (2018) found that video game encounters have positive impact on a students' STEM attitude through the mediating function of computer self-efficacy and expressive costs. The findings of this study do not conform to most of the literature reviewed in Chapter 2.

The interpretation of these claims is that the positive association between the use of game-oriented learning and student performance and attitude toward learning are dependent on other factors. Putting such interpretation into the context of the findings of this study, it is possible that the insignificant difference between the scores of users and non-users of Prodigy depends on other factors, rather than the simple use or non-use of the game. However, these factors could not be identified from the findings, as other factors were not considered in data collection and analysis. Moreover, without knowledge about students' background information, it remains unclear whether all students who played Prodigy were equal in terms of academic capabilities and attitude toward learning compared to those who did not use the game for learning. Perhaps participants who used the game would not be performing similarly with the control group if the game had not been introduced as part of the learning process. Nevertheless, such insight cannot be gained without considering other data and factors about the participants or the manner of instruction used with the students.

Limitations of the Study

Several factors have limited this study. The major limitation for this study was the use of available archival data the district had for third-grade students using Prodigy during the 2017–2018 academic year. When using secondary data, decomposition of data cannot be performed to conduct further analysis. For example, the data cannot be broken down into the amount of time individual students spent on Prodigy, only that the third-grade students were in a classroom that did or did not use Prodigy during the 2017–2018 academic year. Moreover, I could not add data whenever there was missing information. Because of this limitation, the findings and the kind of analysis performed were limited to the data available. For example, *t*-tests were not performed to determine differences in study groups because of assumption violations given the available data. Further analysis to explain the findings could not be performed because other information cannot be determined using the existing data from the archives used.

Another limitation is the use of a quantitative comparative study. Although the findings are valid based on the data collected, I could not perform further data collection—specifically, interviews—to conduct follow-up procedures to explain the findings. In relation to the first limitation and the use of quantitative methodology, students whose data are included in the study, could not be contacted for follow-up questions. Nevertheless, future researchers could explore these limitations to improve the understanding of the findings from this study.

Recommendations

The recommendations for future research are presented based on the limitations of this study. The first recommendation is to conduct an experimental research study using preliminary data collected about the mathematics performance of students using EVGs or Prodigy Game and those that do not. In this manner, data can be broken down to allow for further analysis. By using primary data, any missing data could be addressed properly. Moreover, whenever there is need to collect more data, the researcher could do so by simply adding more participants into the experimental group and control groups.

The second recommendation is to include other factors in relation to use of EVG to verify if EVG has a direct impact on Mathematics performance for the third graders or a possible mediating role in the relationship of variables. Based on literature reviewed in chapter 2, positive association between the use of game-oriented learning and student performance and attitude towards learning may be dependent on other factors (Ball et al., 2018; Shu & Liu, 2019). Therefore, exploring other factors could provide opportunities for further analysis and insights on the use of EVGs or Prodigy Game in the Mathematics performance of students.

The third recommendation is to collect qualitative data and conduct follow-up interviews. By collecting information after analyzing the quantitative data, the researcher could gain deeper knowledge about the significance or insignificance of relationships between variables. Moreover, follow-up interviews could allow for clarification and discussion of data interpretations with participants themselves. Also, experts may be consulted regarding the findings as part of the follow-up procedures to gather more information and gain comprehensive understanding of the findings from quantitative statistical analysis.

Implications

Implications of the study are based on the interpretations of the findings. The first implication is the knowledge that the use of EVGs for learning may not always result in significant improvements in the academic performance of students when compared with other non-users of EVGs. Nevertheless, this insignificant difference may be attributed to other factors that influenced the performance of students, rather than the use or non-use of EVGs alone. This can only be clarified through a controlled experimental design that considers student-related factors such as previous academic performance and attitude towards learning.

Another implication of the findings is that EVGs may be used on a case-to-case basis. The findings of the study could imply that when using EVGs for learning, other factors must be considered. Overwhelming amount of research has shown the important impact of using EVGs for learning. However, with the result of this study, reassessment of cases where EVGs may no longer be needed could also be done to prevent unnecessary use of resources.

There is also a need to reassess policies and programs for children, depending on their needs and against the requirements for implementing the EVG. EVGs have time and monetary resource requirements. Because it has been shown through this study that in some cases, the use of EVGs may not result in improved academic performance of a students, a careful assessment of the benefits and costs of EVG use may be considered before fully implementing its use for all students.

Based on the results, another practical implication is the need to look further into the other aspects of children's' performance, instead of focusing on whether academic performance is improved or not. As previously mentioned, the use of EVGs, specifically Prodigy Game, is not always resulting in better academic performance of students, when compared to those not using the same game. This finding may imply that other aspects may be checked if improvement is observed or not before concluding the insignificant impact of the EVG to the overall performance of students.

In terms of positive social change, the findings may imply that policies and programs on EVG use need to be drafted to fit the needs and capabilities of students. Not all students necessarily perform better academically with the use of EVGs. Such policies and programs could be helpful in ensuring that the use of gamification and EVGs in learning could be fruitful for students and teachers as well. Society, in general, will benefit from the reassessment and modifications of policies and programs regarding the use of EVGs in classes, because students, parent, and teachers, who are members of society, will no longer allot time and resources for EVGs that may not lead to improved academic performance.

Conclusion

Several researchers have attested to the positive impact of gamification and EVG usage in learning to the engagement and academic performance of students. However, in this study using valid data and analysis procedures, it was found that an EVG, such as

Prodigy Game, did not necessarily result in a significant improvement or deterioration in the performance of students when compared to non-users of the game. Based on this result, several implications were identified: (a) other factors may have influenced the insignificant difference in scores, (b) the recommendation of using EVGs, specifically Prodigy Game, to improve mathematics scores may be on a case-to-case basis, (c) policies and programs for using EVGs must consider students' academic capabilities and attitude towards learning. Overall, the findings advanced the current knowledge base on the use of EVGs. Resulting in an uncommon finding means that further research could be done to gain deeper understanding into the use of EVGs for learning. The role of EVGs to improve students' performance in school may not be as simple as the option to use or not to use this strategy for learning. Therefore, other factors must be considered when incorporating EVGs in the learning set-up to fully maximize the potential of the strategy to improve the performance of students.

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