5-2018

The Effect of Game-Based Learning on Title 1 Elementary Students' Math Achievement

LaDonna Martin
Concordia University - Portland

The Effect of Game-Based Learning on Title 1 Elementary Students' Math Achievement

LaDonna Noranne Martin

Concordia University–Portland

College of Education

Dissertation submitted to the Faculty of the College of Education

in partial fulfillment of the requirements for the degree of

Doctor of Education in Teacher Leadership

Sally Evans Ed.D., Faculty Chair Dissertation Committee

Eileen St. John Ed.D., Content Specialist

Kallen Dace Ed.D., Content Reader

Concordia University–Portland

2018

Abstract

The purpose of this quasi-experimental study was to investigate game-based learning, using a computer game system as a supplementary tool in math for elementary students in a low-income Title 1 school. The research question asked, "What are the effects of a game-based learning supplemental instruction on math achievement of Title 1 students?" The null hypothesis was rejected for all five hypotheses. Dreambox is a research-based computer game system that is aligned according to various curricula needs to meet the fourth-grade standards. Four fourth-grade classes, two classes each, were divided into a comparative group and an experiential group. Both the groups were administered the Test of Mathematical Ability-3 pretest. The experiential group received treatment via a computer game system for a seven-week period; whereas, the comparative group received instructions through traditional approaches. Both the groups were given Test of Mathematical Ability-3 as a pre- and posttest. They were tested in (a) mathematical symbols and concepts, (b) math computation, (c) math in everyday life, and (d) math word problem-solving. The independent t-test was used to compare the mean of the pre- and posttest scores of the groups on the afore-mentioned four subtests. The results indicated the experiential group exceeded the comparative group in all four areas: (a) Recognizing mathematical symbols, Subtest 1, experiential group: $M = 3.20$, $SD = 2.02$; comparative group: $M = .60$, $SD = 2.79$); (b) math computation, Subtest 2, experiential group: $M = 3.58$, $SD = 2.30$; comparative group: $M = 1.70$, $SD = 1.87$); (c) math in everyday life, Subtest 3, experiential group: $M = 3.73$, $SD = 1.83$; comparative group: $M = .95$, $SD = 3.15$); and (d) math word problem-solving, Subtest 4: experiential group: $M = 3.68$, $SD = 1.85$; comparative group: $M = 1.40$, $SD = 6.42$). The difference in improvement between the comparative group and experiential group demonstrated that game-based learning had the potential to benefit students academically. In addition, game-based treatment helped students in the experiential group to develop a positive attitude toward math. Utilizing game instruction as a supplement proves advantageous and helps to promote learning and positive attitudes for students of math.

Keywords: game-based learning, low-income, Title 1, mathematics, achievement.

Dedication

This dissertation is dedicated to Mae E. Martin, who passed the baton, and to all my peers in education.

Acknowledgments

Special thanks to the Concordia faculty for their continued support, Conley for the resources provided which made completing this study possible, and my friends and family, who prayed and celebrated.

Table of Contents

Abstract ii

Dedication iv

Acknowledgements v

List of Tables xi

List of Figures xii

Chapter 1: Introduction 1

Background 2

Game-Based Learning and Student Motivation 3

Game-Based Learning and Student Engagement 4

Game-Based Learning and Student Confidence 5

Game-Based Learning and Student Achievement 5

Problem Statement 6

Purpose of the Study 7

Significance of the Study 7

Research Question and Hypotheses 7

Research Design 8

Assumptions, Limitations, and Delimitations 10

Summary 11

Chapter 2: Introduction to the Literature Review 12

Conceptual Framework 15

Technology and Game-Based Learning 19

Achievement Gaps for Low-Income Learners in Elementary Mathematics 20

The Effect of Game-Based Learning on Student Motivation..21
The Effect of Game-Based Learning on Student Engagement 24
The Effect of Game-Based Learning Effect on Elementary School
Students' Confidence 27
The Effect of Game-Based Learning on Elementary School Students' Achievement....28
Literature Methodology 32
Methodological Issues 34
Randomization Design 34
Quasi-Experimental Design..36
Pretest, Posttest Designs 39
Control Group Design 40
Independent T-Test..42
Dreambox Learning...43
Features and performance 44
Test of Mathematical Abilities 45
Synthesis of Previous Research 47
Critique of Research Findings 49
Summary...51
Chapter 3: Methodology 52
Purpose of the Study...53
Research Questions and Hypotheses 53
Research Design 54
Target Population 56

Sampling Method 57
Intervention...58
Instrumentation..59
Data Collection...62
Operationalization of Variables..63
Data Analysis Procedures..64
Limitations and Delimitations of the Research Design 65
Internal and External Validity 65
Expected Findings 67
Ethical Issues 67
Summary..68
Chapter 4: Results and Analysis 70
Description of Sample 71
Summary of Results...71
Independent T-Test Terminologies 73
Outliers-Boxplots 74
Normality-Shapiro-Wilk..75
Homogeneity-Levene’s 76
Additional Statistics...76
Effect size 76
Confidence interval 77
Welch- 77
Independent t-test 77

Detailed Analysis 78

First Hypothesis: H01 78

Second Hypothesis: H02 80

Third Hypothesis: H03 81

Fourth Hypothesis: H04 84

Fifth Hypothesis: H05 85

Summary of Results 88

Subtest 1 88

Subtest 2 88

Subtest 3 89

Subtest 4 89

Supplemental Attitude Subtest 89

Summary 90

Chapter 5: Conclusions 92

Summary of Results 92

First Hypothesis: H01 93

Second Hypothesis: H02 93

Third Hypothesis: H03 94

Fourth Hypothesis: H04 95

Fifth Hypothesis: H05 95

Subtests 95

Subtest 1 96

Subtest 2 96

Subtest 3 96

Subtest 4 97

Supplemental Attitude Test 97

Discussion of Results..98

Discussions of Results in Relation to Literature..99

Limitations..100

Implications of the Results for Practice, Policy, and Theory 101

Recommendations for Further Research 102

Conclusions..103

References...104

List of Tables

Table 1 Demographics of Sample 71

Table 2 Pretest and Posttest Descriptive Statistics...79

Table 3 Mean Gain Scores for Control and Experimental Group......................................79

Table 4 Independent Samples Test 79

Table 5 Pretest and Posttest Descriptive Statistics...81

Table 6 Mean Gain Scores for Control and Experimental Group......................................81

Table 7 Independent Samples Test 81

Table 8 Pretest and Posttest Descriptive Statistics 83

Table 9 Mean Gain Scores for the Control and Experimental Groups 83

Table 10 Independent Samples Test 83

Table 11 Pretest and Posttest Descriptive Statistics...85

Table 12 Mean Gain Scores for the Control and Experimental Groups 85

Table 13 Independent Samples Test 85

Table 14 Pre- and Post-Descriptive Statistics..87

Table 15 Mean Gain Scores for the Control and Experimental Groups 87

Table 16 Independent Samples Test 87

List of Figures

Figure 1. Boxplot with outlier score. 75

Figure 2. Normally distributed data curve. 75

Chapter 1: Introduction

Working and living in the 21st century global economy requires mathematical skills (Hanushek, Woessmann, & Peterson, 2012). As math is an integral part of the practical everyday life, it is vital for learners to excel mathematically (Qian & Clark, 2014; Yong, 2010). Along with more advanced applications, math skills are required for college readiness and are essential in preparing for career development (Abraham, Slate, Saxon, & Barnes, 2014). The everyday need for math skills alone shows that logical reasoning and problem-solving inherent in math are crucial for 21st century living (Brookhart, 2014; Heitin, 2016). However, mathematics test scores have continued to decline nationally. The percentage of students in United States who scored the highest levels on math tests was lower than the international average (Organization for Economic Cooperation and Development, OECD, 2013).

Because game-based learning has been successfully adopted to improve math scores among average students (Byun & Loh, 2015), it has become one strategy in the curriculum used to improve mathematics scores. The reasoning for such incorporation is that results from game-based learning have resulted in positive achievement outcomes for math learners in general (Eseryel, Law, Ifenthaler, Ge1, & Miller, 2014; Hung, Hwang, & Haung, 2014; Woo, 2014). Researchers argued that game-based learning can be used to enhance confidence, motivation, engagement, and achievement related to math (Hsieh, Lin, & Hou, 2016; Filsecker & Hickey, 2014). However, few studies have addressed game-based learning with respect to low-income learners (Berger & Archer, 2015).

Available literature indicated that low socio-economic students are the majority in most of the public schools within the United States (Berg, 2010; Suitts, 2015). The students in the bottom quintile of family socioeconomic status consistently score more than a standard deviation below those in the top quintile on standardized tests in math when they enter kindergarten (Dickinson & Jill, 2014; Reardon, 2013). This study explored game-based learning as a supplement to math curriculum for fourth-grade low-income learners.

This study's primary intention was to investigate the effects of game-based learning regarding fourth-grade Title 1 elementary students' math achievement. The game-based approach was explored as an alternative curriculum support for minimizing the achievement gap of fourth-grade low-income learners in mathematics. This study added to the limited literature concerning game-based learning for elementary and low-income students in mathematics.

Background

Game-based learning is rooted in learning processes inherent in behaviorism theories, cognitivism, constructivism, and flow theory (Ertmer & Newby, 2013; Kim, Roh, & Cho, 2016; Li & Tsai, 2013). The learning theories propose that game-based learning engage students behaviorally and cognitively (Plass, Homer, & Kinzer, 2015) and are linked to student motivation, engagement, confidence, and achievement (Su & Cheng, 2014; Woo, 2014; Ya-Ting, 2012). The majority of researchers have supported game-based learning as a positive supplement to math curriculum (Kalchman, 2011; McNeal, 2016; Mustafa, Khan, & Ullah, 2011).

Behaviorists consider learning to be produced by stimulation and reinforcement (Ertmer & Newby, 2013). The elements of behaviorist theory are exemplified through the gaming process, as computer games often offer reward or punishment for an intended behavior (Ertmer & Newby, 2013). Cognitivism is a theory that principally describes the thinking processes involved in game-based learning (Yilmaz, 2011) and is displayed when players observe, reflect, and follow the rules and processes when interacting within the game (Wu, Hsiao, Wu, Lin, & Huang, 2012).

Constructivist theory emphasizes learning by doing (Ke, Xie, & Xie, 2015; Kim et al., 2016), an interactive learning process of doing inherent within game-play. Game play is innately interactive, which constructivists describe as a necessary component of learning (Liu et al., 2016). Flow theory is a state of complete consciousness and engagement that a person experiences when he or she is totally involved, in an enjoyable sense, in an activity (Miller, Robertson, Hudson, & Shimi, 2012). Flow theory provides a framework for the game-based experience, as students become completely immersed in the challenges and task at hand (Sharek & Wiebe, 2011).

Game-Based Learning and Student Motivation

Researchers suggested that motivation is fundamental in enhancing student learning gains (Park & Yun, 2018). Game-based learning environments have vast potential for improving student motivation (Naik, 2015). Motivation represents the ability to direct behavior through the mechanisms that control emotions (Ruiz-Gallardo, Verde, & Valdés, 2013). The majority of the structures present in electronic games include active participation, promptness, and intrinsic feedback along with a blend of open-endedness and uncertainty that contribute to motivation (Carr, 2012).

Researchers have measured a wide range of recent game-based learning studies as to motivational components, which supported the motivational enhancement of utilizing games for learning math (Kebritchi, Hirumi, & Bai, 2010; Ruiz-Gallardo et al., 2013; Ya-Ting, 2012). According to Ya-Ting (2012), games elicit student curiosity and, thereby, promote engagement and motivation. Kebritchi et al. (2010) found that game-based learning was able to decrease student reservations toward math and increase motivation.

Game-Based Learning and Student Engagement

Engagement constitutes part of the learning process that aids a student to remain connected and involved in an experience, in a way that he/she will persevere in challenging situations (Callaghan, McCusker, Losada, Harkin, & Wilson, 2013). Computer games are effective tools because they sustain interest and attention. The game-based learner is directly engaged in the process of exploring outcomes (Filsecker & Hickey, 2014). The interactivity between the game and the learner produces positive results in math (Kapp, 2012).

Increased engagement was evidenced in studies observing game-based environments (Hsieh et al., 2016). A resource classification matching game called Happy Black-faced Spoonbill demonstrated the potential to keep students involved and escalated student engagement behaviors (Hsieh et al., 2016). Similarly, Hung, Huang, and Hwang (2014) developed a game-based environment through e-books. The students were captivated, which in turn resulted in enjoyment, less anxiety, and sustained engagement.

Some studies warn that the engaging potential of video games could be problematic (Felicia, 2014; Fengfeng, 2008; Zhang, 2015). If students were distracted by the entertainment component of a game, then learning could be inhibited (Fengfeng, 2008). Researchers suggested that games supporting mathematics must be rooted in instruction (Zhang, 2015); that games should not be left to students as ancillary enrichment. The mathematical curriculum should be core when paralleled with game support (Fengfeng, 2008). Overall, a game-based environment has established immense potential for increasing student engagement (Kim et al., 2017; Plass, Homer, & Kinzer, 2015).

Game-Based Learning and Student Confidence

Student confidence is a predictor of a learners' learning behavior, such as the degree of effort made and the expectation of outcomes (Maclellan, 2013). A reduced expectation of success in an area usually inhibits the confidence and motivation for further learning in the concerned area and, therefore, leads to poorer outcomes (Lisciandro, Jones, & Geerlings, 2018). Academic self-concept is crucial for a student to realize his/her academic potential in a subject (Marsh & Scalas, 2011). Game-based learning has demonstrated the potential to increase student confidence in mathematics (Song & Jeong, 2015).

Ku and colleagues (2014) found that digital games can be adopted to enhance students' confidence toward mathematics and to improve students' learning performance. The Fennema-Sherman Mathematics attitude scales revealed a significant increase in students' self-confidence (Ku et al., 2014). Students who participated in digital games were more confident than students who did not. Student confidence is pertinent to learning and is a positive outcome of game-based learning (Fengfeng, 2008; Ku et al., 2014).

Game-Based Learning and Student Achievement

Researchers contended that executing game-based learning to support education is critical to student achievement (Hsieh et al., 2016). Increased achievement through game-based learning is notable in mathematics. Studies concerning the relationships between game-based learning and mathematics achievement are diverse (Gerber et al., 2014). However, the majority of the research supports game-based learning as an agent of student achievement (Fengfeng, 2008; Hsieh et al., 2016; Ku et al., 2014; Sabourin & Lester, 2014).

Shin, Sutherland, Norris, and Soloway. (2012) found that game-based learning elicits substantial academic improvements for elementary students. Additionally, non-digital games have demonstrated the ability to improve learning outcomes. Laski and Siegler (2014) found that a number of board games facilitated student numerical processing and curricula knowledge. Game-based learning has been shown to enhance students' overall academic aptitude (Byun & Loh, 2015).

Not all studies resulted in positive conclusions. One of the exceptions to the positive impact of computers on student achievement is a study conducted by Zhang (2015). The investigation found a negative correlation between students' activity with game sites and the fourth graders' performance in math. Conversely, Zhang (2015) noted that the games were not a part of any pedagogy. Zhang (2015) acknowledged that instructional games with teacher directives could yield other results.

There are a limited number of rigorous studies exploring the effects of game-based learning concerning math skills development (Panoutsopoulos & Sampson, 2012). Specific studies encompassing low-income learners are particularly scarce (Berger & Archer, 2015; Hsin, Li, & Tsai, 2014; Lee, 2012; Vrgute et al., 2015). Mathematical achievement is inconsistent across socio-economic representation in classrooms (Berger & Archer, 2015). Further research is warranted to investigate the effects of game-based learning on low-income elementary students' math achievement.

Problem Statement

This study was designed to add on to the research in game-based learning by extending it to the fourth-grade elementary school learners attending a Title 1 school. Mathematical achievement is inconsistent across socio-economic representation in classrooms (Berger & Archer, 2015). Although the literature has addressed game-based learning for student math achievement, only a few studies have specifically addressed the low-income learners (Berger &

Archer, 2015; Hsin et al., 2014; Lee, 2012; Vrgute et al., 2015). The gap in the literature is addressed by this investigation.

Purpose of the Study

The primary intention of this study was to investigate the effects of game-based learning on Title 1 elementary students' math achievement. The game-based approach was explored as an alternative curricula support for minimizing the achievement gap of fourth-grade low-income learners in mathematics. Lastly, the intention was to add to the limited literature on game-based learning for elementary and low-income students in mathematics.

Significance of the Study

This study contributed to the literature concerning game-based learning. Game-based learning is being increasingly investigated, but research on low-income learners is currently limited. Addressing the learner through effective learning strategies, such as game-based learning, could potentially improve the low socio-economic students' math achievement (Berger & Archer, 2015). However, there are gaps in the literature as to the connection between socio-economic status and game-based learning that have not been widely researched. The results of this investigation extended studies to Title 1 learners, thereby increasing the knowledge of game-based environments. Educators are further exposed to research on game-based learning and math supports concerning the fourth-grade low-income Title 1 elementary students.

Research Question and Hypotheses

The study was guided by the following research question: "What are the effects of a game-based learning supplemental instruction on math achievement of Title 1 students?" The following hypotheses were tested during the study:

H_01 There is no effect for game-based learning instruction on fourth-grade Title 1 learners' achievement in recognizing the signs and symbols related to mathematics.

H_02 There is no effect for game-based learning instruction on fourth-grade Title 1 learners' achievement in mathematical computation.

H_03 There is no effect for game-based learning instruction on fourth-grade Title 1 learners' achievement in understanding mathematics related to everyday life.

H_04 There is no effect for game-based learning instruction on fourth-grade Title 1 learners' achievement in mathematical word problem-solving.

H_05 There is no effect for game-based learning instruction on fourth-grade Title 1 learners' attitude toward mathematics.

Research Design

Quantitative research methods were used for this study. The population in this study was fourth-grade Title 1 learners. Specifically, the targeted population for this study included the fourth-grade Title 1 learners attending a Title 1 district school in the southern region of the United States. Quantitative research focuses on expressing research phenomenon numerically and investigates the degree of homogeneity in characteristics of the concerned study population. This type of data used increases objectivity through statistical, mathematical, or numerical analysis of the collected data. The technique is deductive in nature, and the statistical analysis enhances the impartiality of the conclusions that are drawn from the research findings. Quantitative research was most suitable for this study because of its allowance of the researcher to investigate the relationship between game-based learning and math achievement of fourth-grade Title 1 learners.

Specifically, a quasi-experimental research design was used for the study. Quasi-experimental design compares an experimental group to a control group where full randomization is not possible. It would be difficult to choose students in a public school setting at random and place them in specific groups and classes, thus a quasi-experimental design was the best design for this study. A quasi-experimental design entails an intentional introduction of treatment, procedure, or program to observe the results or outcomes.

One of the most adopted types of quasi-experimental research is the pretest and posttest with a control group design. The design is commonly preferred as it facilitates control over threats to internal validity. Participants were assigned to two groups: the experimental (experiential) group (Group A), which undergoes the treatment/intervention and the control group (Group B), which is not subjected to any conditioning. The control group serves as the benchmark for the comparison. In this design, the researcher performed two distinct measures: the pretests and the posttests for the two groups. Through the posttests, the researcher was able to gain evidence of a valid implication of the intervention in the experimental group (Ellis & Levy, 2009).

Both the pretest and posttest techniques alongside a control group quasi-experimental design were adopted for this study. The principals provided the researcher with data regarding low-income student percentages. Four Title 1 fourth-grade classes were targeted. The classes were located in Title 1 schools. Two classes were assigned to the experimental (experiential) group, whereas the remaining two served as the control group.

The experimental (experiential) group was treated with the Dreambox Learning system. The program content was based on the state curricula standards. Dreambox was found to have a positive correlation to improvement regarding the test scores (Mathewson, 2016). Dreambox

Learning has shown improvements on standardized test scores, resulting in closing achievement gaps (Dreambox Learning, 2016). There has been substantial research supporting its credentials as an applicable system in game-based learning (Mathewson, 2016).

The primary data was collected through the Test of Mathematical Ability (TOMA-3), which facilitated the evaluation of the students' mathematical abilities. The TOMA-3 is a research-based peer reviewed instrument. The students were required to take the test before the experimental (experiential) group was exposed to a game-based learning environment (pretest) and again after the group was exposed to the environment (posttest). The researcher was able to compare the effect of the game-learning environment on the students' math capabilities. The TOMA-3 data provided the primary information for this study.

Assumptions, Limitations, and Delimitations

It was assumed that the fourth-grade learners would actively participate. The students were expected to fully engage in the directives mandated by the study. This study's focus was restricted to only investigating the effects of game-based learning on the math achievement of the fourth-grade Title 1 elementary learners in a school site. Findings, therefore, are not generalizable across other students' sub-groups. Additionally, the mathematical curriculum was based solely on a state in the southern part of the United States. Therefore, the study findings might not be generalizable to the curriculum standards of the other states. Although the curriculum is the same for all the fourth-grade classes, the teachers may have used different strategies that might pose as a limitation to the study. Attendance of the experimental participants might be a limitation if attendance was inconsistent. Again, this study was limited to Dreambox, which might hinder the ability to infer meaning beyond the findings based on the Dreambox game system. There are also limitations due to the small sample size.

Summary

Chapter 1 introduces the framework of game-based learning. Theoretical processes inherent in behaviorism, cognitivism, constructivism, and flow theory provide a foundation for the effectiveness of the game-based environment (Ertmer & Newby, 2013; Kim et al., 2016; Li & Tsai, 2013). Game-based learning has demonstrated positive outcomes for student motivation, engagement, confidence, and achievement (Hsieh et al., 2016; Ku et al., 2014; Filsecker & Hickey, 2014). These results are limited to the general education population. A study investigating the effects of game-based learning on the Title 1 fourth-grade students' math achievement is significant. Chapter 1 reviews the purpose, research question, and hypotheses connected to the research objective. The research design and assumptions connected to this study are also explored in the chapter. This chapter introduces game-based learning and its potential for the low-income Title 1 elementary learners.

Chapter 2 is an examination of the literature review. The researcher established a conceptual framework as to the effectiveness of game-based learning. The literature review is an exploration of the research on game-based learning outcomes. The researcher in Chapter 2 also addressed literature methodology and methodological issues as well as defining research designs along with a synthesis of previous research. Chapter 2 is concluded with a critique of the research findings and a chapter summary.

Chapter 2: Introduction to the Literature Review

It is essential for students to excel mathematically to compete in the global economy (Hanushek, Peterson, & Woessman, 2010). Math is no longer a solitary subject, as math is integrated into our everyday lives (Jansen, Schmitz, & van der Maas, 2016; Kalchman, 2011). The skills are used for practical everyday applications from paying bills to more advanced applications (Kalchman, 2011). Mathematics allows students to develop skills related to logical reasoning and problem solving that are crucial for 21st century living (Brookhart, 2014; Heitin, 2016). Skills in mathematics are critical for living and working in the 21st century (Heitin, 2016; Kim et al., 2016; Mokmin & Masood, 2015; Smaldino, 2011).

Despite the necessity of math skills, learning mathematics presents challenges for the students and instructor (Ku et al., 2014; Sabourin & Lester, 2014). The instructor has to motivate the students to want to spend their time learning and engaging in mathematical activities. Coupled with this challenge, the instructor has to help students to cognitively construct mathematical knowledge (Ku et al., 2014; Smeda, Dakich, & Sharda, 2014). These challenges can be overwhelming and can lead to low confidence, motivation and, subsequently, low achievement (Buchinger & Hounsell, 2018; Ku et al., 2014).

Confidence, motivation, and engagement play critical roles in learning (Jeng-Chung, 2014). They act as the predictors of a learner’s learning behavior including the level of effort applied and the expectation of outcomes (Mata, Monteiro, & Peixoto, 2012). Game-based learning is shown through research as a viable means of enhancing the students’ self-confidence, motivation, engagement, and, ultimately, achievement in mathematics (Fengfeng, 2008; Hsieh et al., 2016; Ku et al., 2014; Sabourin & Lester, 2014). Research related to game-based learning and its efficacy has implications for math instruction related to elementary students and potentially for students from low-income backgrounds (Berger & Archer, 2015; Hsin et al., 2014).

Game-based learning has the capacity to promote learning and instruction (Clark, 2014). Using games in learning can increase the learners' level of motivation, interest, engagement, confidence, achievement, and learning (Eseryel et al., 2014; Hung et al., 2014; Woo, 2014). Computer games benefit math instruction by making a diversity of vivid, comprehensive, and realistic problem-solving contexts, easily accessible (Miller, Baker, & Rossi, 2014). Hands-on games are interactive, engaging, and enhance attitudes and academic achievement (Festus & Adeyeye, 2012). The interactive representations that games encompass can directly enhance the learning outcomes (Habgood & Ainsworth, 2011). Games, whether digital or non-digital, have the potential to improve student confidence, learning motivation, and performance (Felicia, 2014; Smeda et al., 2014).

Even though the literature has addressed game-based learning for improving students' math achievement, there are a few studies that have specifically addressed the low-income learners (Berger & Archer, 2015; Hsin et al., 2014; Lee, 2012; Vrgute et al., 2015). Mathematical achievement is inconsistent across socio-economic representation in classrooms (Berger & Archer, 2015). A lack of resources coupled by less engagement, drive, motivation, and self-beliefs contribute to low-income student's lack of success (Razza, Martin, & Brooks-Gunn, 2012). Significant gaps in mathematics achievement have not closed over decades (Reardon, 2013). The students in the bottom quintile of family socioeconomic status score more than a standard deviation below than those in the top quintile on the standardized tests in math when they enter kindergarten (Dickinson & Jill, 2014; Reardon, 2013). Only 13% students from poor families are at the proficient or advanced academic levels as compared to 38% of students from non-poor families (Nasir, 2016). When there are 30% poor households in a community, these high levels of poverty have a negative and significant effect (Colclough, 2012). Educators have attempted a variety of strategies addressing the socio-economic status and must continue to address these achievement gaps (Stacy, Cartwright, Arwood, Canfield, & Kloos, 2017).

Investigated for the literature review was the research on game-based learning. Explored was the effect game-based learning has on alleviating the pressures of the academic setting for the students. Game-based learning fosters intrinsic motivation and self-confidence as students are free to explore, collaborate, and subsequently learn from the math-based games (Eseryel et al., 2014; Habgood & Ainsworth, 2011; Hung et al., 2014; Ku et al., 2014; Vrgute et al., 2015).

Educational games have a positive influence on student engagement and achievement as well as on the meta-cognitive skills, such as reasoning, memory, logic, problem-solving, and higher order thinking skills (Ku et al., 2014; Lin, Hsieh, Hou, Yen, Chou, & Chen, 2011**;** Liu & Chen, 2013; Mustafa et al, 2011). The effects of game-based learning on student math achievement have been addressed in the research but few studies have specifically focused on the low-income learners (Berger & Archer, 2015, 2016; Hsin et al., 2014; Lee, 2012; Vrgute et al., 2015).

Research has focused mainly on investigating the game-based learning's effectiveness in terms of its accompanying instructional strategies, learning achievements, motivation, and engagement (Eseryel et al., 2014; Habgood & Ainsworth, 2011; Hung et al., 2014; Ku et al., 2014; Vrgute et al., 2015). However, the studies evaluating the effects of game-based learning on low-income households are not as prevalent (Berger & Archer, 2016; Ifenthaler, Eseryel, & Ge, 2012). Addressing the learner through effective learning strategies, such as game-based learning, could potentially improve student achievement concerning low socio-economic groups (Parrett

& Budge, 2012; Stacy et al., 2017; Vanneman, Hamilton, Anderson, & Rahman, 2009). This study was designed to fill the gaps in research by investigating the game-based learning effects on the Title 1 learner's math achievement.

This literature review is organized into four main categories. First, a synthesis of research of the effectiveness of game-based learning is presented, including the research studies that have examined the impact of game-based learning on outcome variables, such as student motivation, interest, cognitive skills, and content learning outcomes. Second, a conceptual framework including a review of theory and foundational concepts of learning is documented. Then, methodological research and literature methodologies are explored. Finally, the research findings are synthesized for future application.

Multiple databases including JSTOR, SAGE Premier, Science Direct Journals, Wiley Online Library, and ProQuest among others were used to comprehend the topic of game-based learning. The reviewer accessed articles from the *Journal for Research in Mathematics Education, the Journal of Educational Technology & Society, Educational Technology Research and Development, Early Childhood Education Journal,* and *the Journal of Information Technology Education.* Databases and articles provided the necessary literature for the study.

The literature review strategies included an investigation of the most current qualitative and quantitative research. The main focus of the review was on the influence of game-based learning for the elementary school students. Achievement gaps, specifically among the low socio-economic students, were explored for greater understanding of the needs of the population.

Conceptual Framework

The concept of learning engagement through games and technology has sparked various case studies and investigations (Clark, 2014; Eseryel et al., 2014; Felicia, 2014). Game-based learning has been linked to positive academic outcomes across multiple curriculums and among the learners of various ages and levels (Loh, 2012; Mazza, 2015; Shin et al., 2012). Majority of the research suggested increased motivation and engagement resulted from game-based learning (Eseryel et al., 2014; Ku et al., 2014; Whitton, 2011). The studies conducted have primarily focused on game-based learning versus traditional instruction (Chao, Chen, Star, & Dede, 2016; Rookhuiszen & Theune, 2009). There are notable learning gaps between the low-income learners and their more affluent peers; however, specific attention to the low-income learners and game-based environments has not been sufficiently addressed (Berger & Archer, 2015; Hsin et al., 2014; Lee, 2012; Vrgute et al., 2015).

There is limited research specifically addressing the low-income elementary students' achievement in game-based learning (Hsin et al., 2014; Weigel, 2013). In this study game-based learning is explored as a supplement in math instruction for the Title 1 elementary students in mathematics. Game-based research on fourth-grade Title 1 learners is relevant and necessary to education as it seeks methods to help all learners succeed (Stacy et al., 2017).

Game-based learning has its roots in several learning theories (Raies, Khemaja, & Mejbri, 2018; Wu et al., 2012). Behaviorism, cognitivism, constructivism, and flow theory all address the various aspects of game-based learning (Burguillo, 2010; Ertmer & Newby, 2013). Behavior, thinking, judging, and immersing in tasks are the processes involved while engaging in game-based learning (Admiraal, Huizenga, Akkerman, & Dam, 2011; Cicchino, 2015; Loh, 2012; Wu et al., 2012). Each of the associated or connected learning theory for the tasks forms the foundations that define game-based learning (Burguillo, 2010; Jabbar & Felicia, 2015).

Behaviorists consider learning to be produced by stimulation and reinforcement (Ertmer & Newby, 2013). Behaviorism is based on three main assumptions: first, learning is manifested by a change in behavior; second, the environment shapes behavior; and third, the principles of contiguity and reinforcement are central to explaining the learning process (Cicchino, 2015; Loh, 2012; Watson, 2013). The theory states that rewarding someone for a particular behavior encourages the said behavior's continuance in the same way in a similar situation (Watson, 2013). The reward reinforces behavior (Jabbar & Felicia, 2015; Watson, 2013).

Fundamentals of behaviorist theory are exemplified through the gaming process (Moore, 2011). Computer games offer reward or punishment for an intended behavior (Sun, Chen, & Chu, 2018). Many games require the performance of a repetitive task to achieve some goal or reward (Stanescu, Stefan, & Hauge, 2016). In behaviorist theory, a reward or positive reinforcement is anything that increases the frequency of a behavior (Li & Tsai, 2013; Watson, 2013). The structure and scheduling of rewards are classic behaviorisms that characterize the reward system in many games (Li & Tsai, 2013).

Cognitivism is the study in psychology that focuses on mental processes, including how people perceive, think, remember, learn, solve problems, and direct their attention to one stimulus rather than another (Li & Tsai, 2013; Viale, 2012). Learners participating in a game will need to predict and use logical thinking while engaging in a game (Carenys & Moya, 2016). Cognitivism emphasizes the psychological nature of knowledge, where learning is promoted through cognition (Ertmer & Newby, 2013). Cognitivism is displayed when players observe, reflect, and infer the rules and processes while interacting with a game (Wu et al., 2012). Cognitivism is a principle theory describing the thinking processes involved in game-based learning (Ertmer & Newby, 2013).

Constructivism is a theory that suggests humans construct knowledge through experiences (Stern, 2012). Constructivism emphasizes learning by doing (Ke et al., 2016; Kim et al., 2016). Game-based learning offers opportunity for interaction to construct knowledge (Hsieh, Lin, & Hou, 2016). This type of learning aligns with the theory as game play is innately interactive, which constructivists describe as a necessary component of learning (Liu et al., 2016). Constructivism explains how engagement influences knowledge in game-based learning process (Mayer et al., 2013).

Nakamura and Csikszentmihalyi (2014) introduced the flow theory. Flow theory is a state of complete consciousness and engagement that a person experiences when he or she is totally involved in an activity, which is enjoyable (Miller et al., 2012; Nakamura & Csikszentmihalyi, 2014). This experience is often referred to as the optimal experience, and people who experience flow are often said to be "in the zone" (Challco, Andrade, Borges, Bittencourt, & Isotani, 2016). While experiencing flow, a person is in an emotional state where he or she is so involved with the activity that nothing else around seems to matter (Admiraal et al., 2011). Nakamura and Csikszentmihalyi (2014) defined the phenomena of flow state as having numerous dimensions: clear goals, immediate and unambiguous feedback, and balance between the challenges of an activity. It requires the skills to meet those challenges, concentration on the task at hand, a sense of potential control, loss of self-consciousness, and a distorted sense of time. Games stimulate a flow experience for students (Hsieh et al., 2016). Games are intrinsically motivating and elicit full immersion and, subsequently, learning through the flow experience (Hamari et al., 2016).

The learning process is built into games, grounded in the principles inherent in behaviorism, cognitivism, constructivism, and flow theory, which encompass built-in learning processes (Ertmer & Newby, 2013; Wu et al., 2012). Theories related to game-based learning provide an explanation for how they help in enhancing student achievement (Burguillo, 2010; Naik, 2015). For example, game-based learning engages students behaviorally and cognitively, while providing, through flow experience, opportunities for constructive interactions (Pitt, Borman-Shoap, & Eppich, 2015).

Learning theories address the needs and requirements for student learning and are directly applicable to game-based learning (Nakamura & Csikszentmihalyi; Stern, 2012). Consequently, game-based learning has been utilized as a tool to improve academic achievement (Ruiz-Gallardo et al., 2013). Therefore, an investigation of the effects of game-based learning on the Title 1 learner's mathematical assessment achievement in elementary is merited (Shih, Jheng, & Tseng, 2015). Educational initiatives' aims are to address all the students, particularly the disadvantaged (Stacy et al., 2017). This study attempted to acquire further knowledge regarding the game-based learning process to determine its effects on the disadvantaged student.

Technology and Game-Based Learning

Game-based learning broadly represents the utilization of computer games to support learning and teaching (Wang, Chen, & Chan, 2016). It is anchored on the notion that when children play, they learn (Ostrosky & Meadan, 2010). Computer games help to make the educational process more robust, creative, contemporary, and aligned with the new generations of computer literate pupils, who are accustomed to quicker and more regular interactions (Carenys & Moya, 2016). Principles of game-based learning encompass aspects such as intrinsic motivation (Baek, 2014). One of the principles of game-based learning relates to the notion of learning via intense enjoyment and having fun (Moyle, 2010). Game-based learning also subscribes to the principle of authenticity in the sense that learning is contextualized and goal-centric rather than abstract-based (Tanes & Cho, 2013).

The overriding mechanisms of game-based learning encompass rules (simple and binary) at progressively difficult levels, the use of a fictional setting (fantasy), immediate and constructive feedback, interaction and high-levels of student control, and a social element that enables individuals to build bonds and share experiences (Baek, 2010). Computer games directly support learning by offering students a chance to develop knowledge and cognitive skills (Gerber et al., 2014). Games help students to develop creativity and use their imagination. By playing computer games, the students are able to discover and develop their capacities and skills and acquire experience, learn, and create (Divjak & Tomic, 2011).

Achievement Gaps for Low-Income Learners in Elementary Mathematics

Today, low-income students constitute an ever-larger share of the students' population in the United States (Berg, 2016; Suitts, 2015). Unfortunately, the academic performance of low-income students is typically behind the national average. The achievement gap in education represents inequality in academic performance between various groups of students (OECD, 2014; Vanneman et al., 2009). In their study on achievement gaps in mathematics and reading between White and Latino and African American students in public schools, Vanneman and colleagues (2009) established that low-income learners in elementary math fair worse as compared to the students from more affluent backgrounds in both reading and mathematics. The achievement gap manifests in various aspects, such as grades, standardized-test scores, course selection, and dropout rates among other educational success measures (Berg, 2016; Berger & Archer, 2015).

A part of the reason why students from low-income groups do not fare well in mathematics as compared to their more affluent peers stems from the fact that low-income students lack high levels of instruction and motivation along with not having access to educational resources (Williams, Brule, Kelley, & Skinner, 2018). By qualification measures such as certification, pedagogical training, test scores, subject matter background, and selectivity of the college attended, or experience, it is evident that teachers with fewer qualifications are serving in schools with greater numbers of low-income and minority students (Mangiante, 2010). The interstate research has shown that the probability of students in low income schools to have unqualified teachers is three to ten times as compared to the students in affluent schools (Degol & Bachman, 2015).

Typically, low-income students have limited access to many indicators of educational success including school funding, high curriculum, qualified teachers, materials, books, and computers (Berg, 2016). The highest spending districts in the United States spend approximately 10 times more than the lowest spending ones. The highest spending state (Vermont) spends approximately three times more per pupil (at $17, 552) than the lowest spending state (Utah at $6,586; Adamson & Hammond, 2011). Developing early math skills and surmounting the systemic deficiencies between students of various ethnic and socio-economic backgrounds will demand holistic improvements in the instruction of mathematics (Abramovich, 2010; Ke et al., 2016; Kim et al., 2016).

Thus, to enhance the achievement levels of minority and low-income students, there is a need to focus on enhancing creativity and curriculum standards (Ke et al., 2016; Kim et al., 2016). Improvements in mathematics scores can be affected through the implementation of game-based learning (Vanneman et al., 2009). Most importantly, game-based learning is beneficial to all the students, irrespective of their economic backgrounds and abilities (Hsieh et al., 2016).

The Effect of Game-Based Learning on Student Motivation

The connection between positive affective states, such as curiosity and student learning, has been the subject of mounting attention in recent years (Liu et al., 2016; Woo, 2014; Ya-Ting, 2012). Although the exact cognitive and affective mechanisms underpinning the learning experiences are not yet well established, there has been substantial progress in the attempt to highlight the emotions that students are prone to experience (Mayer et al., 2013). Research on student emotion connected to motivation is continual (Mega, Ronconi, & Beni, 2014).

Affective states, such as curiosity and flow, tend to positively correlate with learning; whereas, adverse states, such as frustration and boredom, manifest a negative effect (Cheon & Reeve, 2015; Pitt et al., 2015). Student motivation and engagement have also been shown to be fundamental in enhancing the learning gains with computer-based learning environments (Sabourin & Lester, 2014). Game-based learning environments provide huge potential for improving student engagement and motivation (Frost, & Eden, 2014; Naik, 2017).

One of the outstanding features of electronic games is their ability to motivate (Pitt et al., 2015). Electronic games feature elements, such as affective feedback, persistence, and self-efficacy, which help in motivating the students (Bourgonjon, Valcke, Soetaert, & Schellens, 2010). Motivation represents the ability to direct behavior via the mechanisms that control one’s emotions (Ruiz-Gallardo et al., 2013). Emotional control is channeled through goals and needs (Li & Lerner, 2013; Naik, 2015). Motivation is an element that ultimately dictates the engagement of the learner (Pitt et al., 2015). The bulk of the features of electronic games, including active participation, prompt and intrinsic feedback, challenging but attainable goals, and a blend of open-endedness and uncertainty contribute to motivation (Carr, 2012; Reeve & Lee, 2014).

Research studies show that well-structured computer games can satisfy some of the psychological needs of children (Carr, 2012; Wang et al., 2016). A wide range of recent game-based learning studies measured motivational components and mainly supported the motivational enhancement of utilizing games for learning (Ruiz-Gallardo et al., 2013). Higher levels of engagement for students enhanced positive attitudes toward math for the fifth graders and the increased motivational levels among the students (Carr, 2012; Fengfeng, 2008; Kebritchi et al., 2010; Mustafa et al., 2011).

Video games enhance students' motivation (Shih et al., 2015). In examining the explanation on why game-based learning possesses an impact on student motivation, Ya-Ting (2012) suggested that by immediately offering students praise, reinforcement, and encouragement, gaming software aided students to develop motivation and confidence to continue with the task. The other explanation for the increase in motivation rests on the fact that the game elicits learner curiosity (Ya-Ting, 2012).

Kebritchi et al. (2010) in a later study confirmed Ya-Ting's (2012) findings about motivation. The authors examined the impacts of contemporary math computer games on the mathematics performance and class motivation (Kebritchi et al., 2010; Ya-Ting, 2012). In their study, the research treatment group employed a game referred to as Dimension MTM (Kebritchi et al., 2010). The game teaches students algebra by engaging players in undertaking mathematics-related missions in a 3-D immersive environment embedded with advanced graphics. Students became more aware of the connection between mathematics and real life. In turn, the connection diminished student's mathematics phobia (Kebritchi et al., 2010). When students played the game, they desired to learn more and pay more attention, because they enjoyed completing the game's missions (Kebritchi et al., 2010). Positive effects of game-based learning decrease student reservations and increase motivation toward math (Kebritchi et al., 2010).

The Effect of Game-Based Learning on Student Engagement

Games can be employed as a tool in the classroom to engage students both psychologically and physiologically. Engagement is pertinent to learning (Byun & Loh, 2015). It constitutes a part of the process that aids a student to remain connected and involved in an experience in a way that he/she will persevere in challenging situations (Callaghan et al., 2013). While playing games, students enjoy opportunities for socialization, choice, and exploration (Fengfeng, 2008; Hsieh et al., 2016). The students' actions in the virtual environment of games improve their engagement with learning activities and associated content (Erhel & Jamet, 2015). Game-based learning helps learners engage personally in undertaking the activities (Eseryel et al., 2014). Since the learner does not receive any ready-made results, he/she is directly engaged in the process of exploring the outcomes (Filsecker & Hickey, 2014).

One of the advantages of games is that games are accommodative to multiple learning styles and provide both interactive and decision context (Hamari et al., 2016). Most importantly, games provide students with a hypothetical environment in which they can explore alternative decisions devoid of the risk of failure (Fry, Ketteridge, & Marshall, 2010). Game techniques such as scaffolding and visual feedback help to foster reflective cognition.

Game-based learning environments are engaging environments. Students achieve significant learning gains through game-based interaction (Hwang, Chiu, & Chen, 2015). For example, in a study conducted by Hsieh et al. (2016), engagement was demonstrated through students' increased involvement in games. There were higher and lower engagement patterns between males and females. However, an increased engagement level was evidenced in the game-based environment (Hsieh et al., 2016). A classification matching game called Happy Black-faced Spoonbill provided the stage for game-based learning in a study conducted by Lin et al. (2011). Synchronous video-capturing systems and web cameras were used to gather scholarly engagement activities (Hsieh et al., 2016).

The web camera gathered facial vocabularies, student vocal postures, and positions to fully comprehend how scholars reacted to the games apparatus. Students seemed to adulate and immerse themselves in the game-based activities (Hsieh et al., 2016). Non-verbal and verbal behaviors guided this study in visualizing the learning process and evidenced that games can reliably escalate students' engagement in the game-based learning environment (Hsieh et al., 2016). Implications from this study suggest that a game-based environment increases student cognitive interactions. Games used provided the potential to keep students involved and escalated student engagement behaviors. Achievement is an optimal result when students are engrossed in an activity (Reyes, Brackett, Rivers, White, & Salovey, 2012). The game-based learning environment captivated students. In this study, engagement was one of the many products of the game-enriched environment (Hsieh et al., 2016).

Educational games foster positive attitudes toward math learning and promote metacognitive awareness among the students (Fengfeng, 2008). Positive attitudes cultivate student engagement (Sengupta-Irving & Enyedy, 2014). Game-based learning fosters a cooperative structure (in which learners work in concert within the game space) as opposed to individualistic or competitive structure (Lester et al., 2014). Collaborative and positive attitudes toward mathematics learning were products of game-based learning (Fengfeng, 2008; Lennon, Moriarty, & Zivkovic, 2014).

Students attain meaningful goals as they solve challenges, quests, and puzzles in video games as a multi-player cooperation is created (Ronimus, Kujala, Tolvanen, & Lyytinen, 2014). However, Fengfeng (2008) also noted that the engaging potential of video games could be, to some extent, problematic owing to the fact that children might be distracted by the entertainment components of the game, especially in cases where the elements are not properly meshed with the instructional components. Hence, video games supporting mathematics ought to strive to be integral instead of being ancillary to the core nature of the subject (Fengfeng, 2008).

The game-based learning environment effectively fosters students' learning achievement, engagement, motivation, and self-efficacy in mathematics (Shernoff, Ruzek, & Sinah, 2016). Quasi-experimental research has shown that immersing students in mathematics games has resulted in positive and engaging outcomes. Hung and colleagues (2014) developed a mathematical game-based learning environment based on the e-books for aiding children; minimizing mathematical anxiety; and enhancing their self-efficacy, achievements, and motivation in learning mathematics. This quasi-experimental research showed that the game-based e-book learning model not only promoted engagement but also student efficiency in mathematics.

A game-based learning environment engages students (Fengfeng, 2008; Hung et al., 2014). Positive attitudes are associated with this engagement (Fengfeng, 2008). Enjoyment also paralleled engagement in a study conducted by Hung and colleagues (2014) where the students experienced less anxiety with digital e-books. These studies highlighted how games increased student engagement. Consequently, cognitive math understanding, and achievement also improved (Fengfeng, 2008; Hung et al., 2014). Game-based learning engaged the participants and the participants' math competencies enhanced (Fengfeng, 2008; Hung et al., 2014). These findings have major implications toward the effectiveness of game-based instruction. Game-based learning produces enjoyment that invokes student engagement. This engagement has a multiplicity of positive outcomes including students learning, achievement, and confidence (Fengfeng, 2008; Hung et al., 2014).

The Effect of Game-Based Learning Effect on Elementary School Students' Confidence

Self-confidence is imperative in learning (Villalon, 2016). Student self-confidence is a predictor of learner outcomes and has been used to interpret the amount of effort made toward math achievement (Maclellan, 2013). Declining confidence and self-assurance represent the resulting learning consequences and impact students' reservations about their ability to master mathematics (Ku et al., 2014). Student confidence is pertinent to learning and is a positive outcome of game-based learning (Maclellan, 2013; Villalon, 2016).

Ku et al. (2014) investigated students' confidence toward mathematics. This study sought to determine whether digital games could be adopted to develop and improve students' learning. Two fourth-grade classes consisting of a control group and experimental group participated in the investigation. Students were divided into high and low ability groups. An experimental group (EG) studied in a digital game-based environment, whereas a control group (CG) studied in a paper-based atmosphere to establish a learning contrast.

Changes in confidence toward mathematics were a result of the utilized game-based learning interventions. This study employed a questionnaire modified from the confidence subscale of the Fennema-Sherman Mathematics attitudes scales (Mesoudi, 2017), which is a renowned investigative instrument used to determine students' opinions toward mathematics (Mesoudi, 2017). Assessments revealed a substantial increase in confidence between the pretest and the posttest for the EG students (Ku et al., 2014).

Results from this investigation revealed that game-based learning was able to increase students' self-efficacy. The students who participated in digital games were more confident than the students who did not (Ku et al., 2014). A digital game-based learning environment provided students with the self-assurance to complete the math tasks (Ku et al., 2014). Students were more confident and resilient after playing digital games (Ku et al., 2014). This research has major implications toward the effect of game-based learning on student efficacy. Student confidence increases because of game-based learning (Ku et al., 2014).

The Effect of Game-Based Learning on Elementary School Students' Achievement

A review of the various studies on the relationships between game-based learning and mathematics achievement reveal the diversity among the studies in terms of purposes and processes (Gerber et al., 2014; McNeal, 2016). Some studies may measure game-based math achievement of males versus females; whereas, others measure math achievement and teacher competency (Park, Gunderson, Tsukayama, Levine, & Beilock, 2016; Steffens, Jelenec, & Noack, 2010). However, a majority of the studies demonstrated that math-based video games contribute to higher learning gains relative to conventional instructional methods (Liu & Chen, 2013; Mustafa et al., 2011; Shin et al., 2012).

The results of various studies in non-experimental, correlational analysis show that hands-on game scores and attitudes toward mathematics aligned significantly to students' scores on mathematical tests (Festus & Adeyeye, 2012; Jong, 2015). The outcomes of quasi-experimental control-group design show that students utilizing game-based learning repeatedly outperformed the students who did not utilize game-based learning (Tobias, Fletcher, & Wind, 2014). The critical value of game-based learning notes that every student experienced enhanced dynamic cognitive processes that boost performance in mathematics (Ke et al., 2016; Kim et al., 2016).

Researchers contended that executing game-based learning to support education is critical to student achievement (Hsieh et al., 2016). Students become intrinsically motivated and register improvements on various attributes, including critical thinking, problem-solving, creativity, innovation, and communication (Ku et al., 2014; Ya-Ting, 2012). A study conducted by Shin et al. (2012) investigated the impact of game technology on student learning in mathematics. The study found significant increases in achievement because of using technology and game-based learning. The students who participated in game-based treatment had substantial improvements (Shin et al., 2012). Two data sets for the study were gathered from slightly varied subjects. In the first set, 41 second graders (7- or 8-years old) from two classes employed either a technology-based game or a paper-based game lasting five weeks. In the next 13 weeks, the two classes utilized technology-based games twice or three times per week. Game-based learning was responsible for better game performance and improved attitudes toward mathematics, which ultimately increased learning (Shin et al., 2012).

Results of the study indicated that utilizing technology-based games within the classroom was beneficial to the students, especially in the learning of arithmetic skills (Shin et al., 2012). Digital games had superior outcomes for students. Technology exceeded the hands-on games in this study, suggesting that digital game-based learning might have a greater influence on student learning outcomes than the hands-on games. Greater achievement was accomplished within this game-based environment (Shin et al., 2012).

Computer-based learning activities have positive effects on students' math performance (Hamari et al., 2016). Game-based learning, specifically computer games, increases math performance (Kebritchi et al., 2010). Socio-economic status was found to heavily influence math achievement (Nesbitt, Baker-Ward, & Willoughby, 2013). Researchers have suggested that game-based instruction can be used as a treatment to remedy the achievement gap in academics, which is related to low-income (Kim & Chang, 2010; Lee, 2012).

Non-technological games can play a pivotal role in enhancing the students' achievement in mathematics and their effect is closely shared among the male and female students (Jayantilal & O'Leary, 2016; Mustafa et al., 2011). In a study conducted to examine the efficacy of game-based teaching approach in a third world country, a non-technological game, Guess and Tell, was employed as a source of teaching mathematical concepts of mode and mean to Grade 8 pupils (Mustafa et al., 2011). Non-digital games were found to be effective in students' mathematical achievement. Gender differences did not affect learner outcomes, as game-based learning increased all the students' academic success (Mustafa et al., 2011). Game-based learning can impact achievement even in non-digital forms (Devonshire et al., 2014).

Games have consistently led to positive outcomes concerning aspects, such as persistence, motivation, curiosity, attention, and attitude toward learning (Jong, Hong, & Yen, 2013; Spires & Lester, 2016). These outcomes act as a catalyst to improve student achievement (Sengupta-Irving & Enyedy, 2014). Games are noted within the elementary curriculum to produce achievement outcomes that are otherwise not accomplished. Laski and Siegler's (2014) study sought to help the elementary school students learn math-related concepts by engaging them in an educational board game. The results of their study showed that the number board game facilitated the students' encoding of the numerical-spatial relations.

The board game improved the students' number line estimates, numeral identification, and count-on skill (Laski & Siegler, 2014). Outside of the context of the mathematical board games, these skills did not improve. The results of this study reinforced the efficacy of educational board games in enhancing the students' mathematical knowledge of numbers and processing (Laski & Siegler, 2014). Games were pertinent as mathematical treatment for the students. Game-based learning in the elementary environment can make the difference between successful and unsuccessful academia (Iten & Petko, 2016).

Game-based learning enhances the students' academic aptitude (Byun & Loh, 2015). Digital game-based learning increases students' academic knowledge of the curriculum vocabulary (Callaghan et al., 2013). Game-based learning supports the curriculum and promotes student achievement. Laski and Siegler's (2014) findings proposed that game-based learning effectively supports knowledge of the curriculum in a way that instruction absent of games does not. The noted cognitive competencies of a game-based environment support game-based learning as a catalyst of achievement (Laski & Siegler, 2014).

Not all the studies support the use of games as a means to achieve student achievement (Hwang et al., 2015; Zhang, 2015). Some studies suggested that students' focus on games hinders the academic focus (Jabbar & Felicia, 2015). One of the exceptions to the positive impact of computers on student achievement is a study conducted by Zhang (2015). The author investigated the connection between interest in online math games and academic performance. The study established a considerable negative correlation between search volumes of the game site and the fourth-grade students' performance in reading and mathematics (Zhang, 2015).

Furthermore, the internet users residing in states with greater numbers of low-income households and fewer college graduates were more probable to search the game site (Zhang, 2015). However, it is essential to recognize that the author offers a caution that there was minimal evidence regarding math games on the website that satisfied the criteria for effective instruction. Hence, gaming might not have been integrated in a concise pedagogic process (Zhang, 2015).

According to Zhang (2015), student interest in math games did not improve their academic performance. It should be noted that instructional pedagogy was not enlisted to direct student learning (Zhang, 2015). Student usage of the non-instructional games was simply observed. Zhang (2015) reported further investigation that instructional games with teacher directives could yield other results. Additional research is needed regarding game-based learning (Ronimus et al., 2014).

Literature Methodology

In studies examined for this literature review, quantitative, qualitative, and mixed methods designs were noted. The designs are based on the research purposes. Quantitative methods best answer the research questions by measuring scores and achievement (Hoe & Hoare, 2013; Mustafa et al., 2011; Shin et al., 2012). Qualitative research examines attitudes toward math (Kebritchi et al., 2010; Sallee, & Flood, 2012). Mixed methods engage both quantitative and qualitative design to simultaneously answer research questions and corroborate findings (Creswell & Plano Clark, 2018; Fengfeng, 2008; Hung et al., 2014). The quantitative data set, however, played a more central role in the literature research.

Qualitative research helped the researchers to determine the students' attitudes toward math. Qualitative research is marked by a comprehensive description of personal action, complex environment and context, and the integrity of its thinking (Stake, 2010). In evaluating a student's confidence and motivation, qualitative research provided insight into learners' emotional responses and thoughts concerning the games and curriculum (Dania & Zounhia, 2016; Kebritchi et al., 2010; Ya-Ting, 2012).

Researchers simultaneously examined variables such as achievement and motivation that were employed in a mixed methods design (Creamer, 2018; Fengfeng, 2008; Hung et al., 2014).

Mixed methods research is a research design in which the researcher uses both qualitative and quantitative data collection and analysis techniques to better understand the real-world problems being studied and to better answer the research questions (Halcomb, & Hickman, 2015). This method was applied to answer the questions of student scores as well as students' opinions of a game-based environment (Fengfeng, 2008; Hung et al., 2014).

The majority of investigations utilized the pre- and posttest quantitative experimental design. Quantitative method includes scrutiny of data using simulation, inferential, and experimental methods to define the relationship between various research variables (Labaree, 2009; Oliver, 2010). Quantitative method was used in determining game-based learning methods' effects on variables such as grades, scores, and progression (Hsieh et al., 2016). The numerical data collected during quantitative studies allows for the concrete comparison of experimental and control groups (Claydon, 2015). The comparison provides a basis for determining student growth and achievement (Ke et al., 2015).

Quantitative methods using quasi-experimental design were used for the research. Quantitative methods emphasize objective measurements and the statistical, mathematical, or numerical analysis of the data collected (Laboree, 2009). Quasi-experimental design compares an experimental (experiential) group to a control (comparative) group; however, the groups are chosen and assigned out of convenience rather than through randomization (Heffner, 2014). This study used a pre- and posttest to measure and compare student growth pertaining to mathematics. Two classes represented the comparative group; whereas, two represented the experiential group. The fact that random sampling was not used makes this a quasi-experimental design (Schaaf, 2012).

Quantitative research focuses on gathering numerical data and generalizing it across groups of people (Whitton, 2012). Previous studies utilized quantitative methods when comparing students' scores and achievement especially those of an experiential and comparative group (Ku et al., 2014; Ya-Ting, 2012). The literature supports quantitative design as it is most appropriate in exploring the effects of game-based learning on students' achievement (Schaaf, 2012). Quantitative research using a quasi-experimental design provides a concrete analysis of student growth and achievement (Whitton, 2012).

Methodological Issues

The strength of quantitative design is a precise, concrete, numerical analysis (Claydon, 2015). The quantitative researcher might construct a situation that eliminates the confounding influence of many variables, allowing credibility that establishes cause-and-effect relationships (Ellis & Levy, 2009). However, there are limitations to this design. Quantitative knowledge might be too abstract and general for the direct application to specific local situations, contexts, and individuals (Kothari, 2008). The lack of random assignment is a particular weakness of this quasi-experimental study design (Feinberg, Salisbury, & Ying, 2016). While true random assignment solidifies experimental research, randomization was not feasible for this study. Quasi-experimental design was the most appropriate.

Randomization Design

Randomization design is a common sampling technique used by the researchers during scientific experiments (Kirk, 2013; Yin, 2018). Unlike quasi-experimental design, randomization is based on the principle of selecting participants for a study by chance instead of choice (Zhao, Weng, Wu, & Palesch, 2011). It ensures that the participants have an equal chance of being selected to participate in a study. The underlying concept of randomization is to reduce bias to a minimum by ensuring the treatment for participants in a study not affected by poor judgement of the researcher (Yin & Campbell, 2018).

The elimination of bias implies that the results of a given study are considered more reliable and valid (Kirk, 2013). Studies have shown that researchers achieve randomization by employing various techniques (Yin & Campbell, 2018; Zhao, Weng, Wu, & Palesch, 2011). The easiest way to achieve randomization is to use computers to generate the random numbers. One might utilize random number tables that are often posted in statistical books. In addition to the stated methods, one might also come up with a plan of performing randomization, such as choosing the last digit of phone numbers in a directory (Zhao et al., 2011).

Nevertheless, there are two main types of randomized designs that have been proposed for use in experiments. They include a randomized block design, which is also known as stratified random sampling, and completely randomized design (Yin & Campbell, 2018). In completely randomized design, the participants in a study are selected entirely at random, based on random numbers generated by a computer, such as the through the SAMPLE command in MINITAB software (Kirk, 2013; Yin & Campbell, 2018). For instance, in this study of game-based learning effects on Title 1 students, random assignment would occur if the students were randomly assigned, irrespective of their age, gender, or even year of study, but solely based on the numbers obtained from the computer.

On the other hand, randomized block design entails participants being separated into homogeneous blocks before they are assigned randomly to their treatment groups. In this study, for instance, randomized block design would be applied by first separating the students into class groups, such as freshman, sophomore, junior, and senior. Thereafter, within each class group, the students are randomly divided into the two groups, that is, those who receive typical instructions and those who receive game-based instructions.

Randomized block design is often used to avoid large disparity in results, such as performance output, and helps to get a better estimate of the treatment within a given block (Yin & Campbell, 2018). Additionally, randomized block design ensures that the whole population of 200 students from which the sample is drawn is properly represented in the selected 80 students. Through randomized block design, all the classes of students would be chosen including the minorities who are at the risk of being omitted in cases where a complete randomized method is employed (Kirk, 2013; Marczyk, DeMatteo, & Festinger, 2010).

However, in the selection process, it becomes difficult to generalize the obtained results to the rest of the population. The sample for the test can be just a small fraction of the population. Consequently, researchers often face the difficult task of selecting a large sample group when dealing with randomization methods to enable them to impose the results of the study on the study's whole population (Marczyk, DeMatteo, & Festinger, 2010).

Quasi-Experimental Design

Quantitative methods emphasize objective measurements and the statistical, mathematical, or numerical analysis of the data collected (Cook, 2015). The aim of a quasi-experimental design is often to prove a cause-and-effect relationship between variables (Campbell & Stanley, 2015). However, it does not utilize a random assignment like true experimental designs. Usually, a random selection of participants in any given study is highly crucial in eliminating bias by ensuring that the study's participants have an equal mixture of the characteristics that are being studied (Campbell & Stanley, 2015). Consequently, randomization helps to improve a research's internal validity (Shadish & Galindo, 2010).

The reason why quasi-experimental design does not utilize random selection is because its chief purpose is often to analyze some particular characteristics found in specific participants (Cook, 2015). For instance, when conducting a research on brain damage and its impact on a given function, one has to select participants with a brain disorder or else the research will be void (Thayer, 2012). In such a case, using a randomization process to select participants would be unethical, because some of them would not suffer from brain damage and, hence, undermine the study's essence (Thayer, 2012). As a result, quasi-experimental designs are used where a researcher needs participants possessing certain pre-existing conditions that cannot be manipulated, such as financial background, gender, strongly held beliefs, or certain disabilities (Campbell & Stanley, 2015; Cook, 2015).

The most used quasi-experimental design is the non-equivalent pretest, posttest model (Shadish & Galindo, 2010). In the model, the participants are first selected based on a pre-existing condition and a pretest is conducted to ascertain that indeed they all have a relatively similar condition. Thereafter, they are divided into two or more groups. In a true experimental design one group would be the control group and the other experimental. Because the quasi-experimental design was utilized, the experimental group will be referred to as the experiential group and the control group as the comparative group. In quasi-experimental design the experiential groups are manipulated by adding variables (Park, 2015; Thayer, 2012). The comparative group's participants are not placed under any new situations (Park, 2015; Thayer, 2012). The results from the experiential group and comparative groups are compared and relevant conclusions made.

For example, a study on sedentary adults with major depressive disorders was assigned to four groups: Placebo pill, antidepressant therapy, home-based exercise, and supervised exercise.

After four months, the patients who were in the exercise and antidepressant groups had higher remission rates (Campbell & Stanley, 2015). The stated example is a quasi-experimental design because it utilized a particular group of participants who had massive depression disorders and also illustrated a cause-and-effect factor by dividing the participants into four groups (Park, 2015).

Even though random assignment is crucial in solidifying an experimental research, it was not feasible for this particular study. Instead, quasi-experimental design was the most appropriate because the study involved comparing two student groups, each comprising of 40 people, where one was controlled and the other was manipulated. The pre-existing condition in this case was that the participants must be students only; whereas, the cause-and-effect relationship was to assess the impact of giving game-based instructions and typical instruction to the two groups involved in the study.

Quasi experiments are noted to be an efficient method of research in psychology and other social sciences. This method also manages the time and resources of a study because randomization and prescreening processes are not required in the selection of the participants (Cook, 2015; Thayer, 2012). The validity is dependent on adherence to ethical standards (Thayer, 2012). Additionally, other variables can influence the final outcome but the focus, when using the method, is on the treatment introduced to the group under study (Shadish & Galindo, 2010). Besides, the sample size from this study is too small to generalize to larger populations. Therefore, achievement of this group might not fully represent the achievements of other groups. Thus, a wider scale research should follow this study to increase the generalizability.

Pretest, Posttest Designs

Pretest, posttest design is mainly used in true experimental designs to compare the degree of change between the participant groups after they undergo a treatment or intervention (Bowen et al., 2009; De-Marcos, Domínguez, Saenz-De-Navarrete, & Pagés, 2014). Most experimental studies utilize pretest and posttest designs due to the simplicity in analyzing the effectiveness of an intervention (De-Marcos et al., 2014). The results before and after the tests are conducted and analyzed. Sometimes, the design employs two groups of participants. One group is undertaken through specified treatment or interventions, and then the results are gathered after completion of the experiment (Bowen et al., 2009).

The other group is considered the control and does not receive any kind of treatment during the entire testing period, but its participants are subjected to similar tests (Bowen et al., 2009). Pretest, posttest design can be used with more than two groups, such as multiple groups become necessary when analyzing the effect of different levels of medicinal dosages (Zientek, Nimon, & Hammack-Brown, 2016). Thereafter, a statistical analysis is carried out to determine whether the treatment or intervention did indeed have a significant effect on the output (Bowen et al., 2009; De-Marcos et al., 2014; Rockwell & Kohn, 1989).

In this study of game-based learning and Title 1 students, the first group, which was comprised of 40 students, was given game-based instructions. An analysis was conducted to assess how the game-based treatment influenced their performances. However, the other group consisting of 40 students represented the control (comparative) group, which was given the typical instructions but were not subjected to any unique set of instructions. Thereafter, an analysis was done to evaluate the group's performance in an ordinary situation without any intervention. This study's key aim was to assess the performance of the intervention group to understand the effectiveness of using game-based instructions.

Although many researchers find many uses for a pretest, posttest design, it poses a threat to a study's internal validity and is also limited in scope (Zientek et al., 2016). The design does not indicate whether the selection of the participants was random but assumes that the participants in control (comparative) and intervention groups are relatively similar (Bowen et al., 2009). In pretest, posttest design, it is extremely difficult to completely separate the participants from each other, as it might compromise the study's outcomes (Bowen et al., 2009). The design has no external validity as it mostly focuses on the changes in the participants before and after the treatment within a single group (Zientek et al., 2016).

Control Group Design

In an attempt to improve the internal validity of studies, researchers often use a control (comparative) group design as a benchmark of analyzing how far the variables introduced in different groups in a test have caused a change in the participants (Becker et al., 2015; Bernerth & Aguinis, 2015). Changes can then be measured statistically. The principle behind this design is that two groups are randomly assigned to participants, but one of the groups is a control (comparative) while the other is a test group (Quirmbach, Lincoln, Feinberg-Gizzo, Ingersoll, & Andrews, 2009).

Before the beginning of the experiment, the participants in both groups are pretested for determining their condition before the introduction of various variables that may be in the form of a medicinal treatment of patients or even seminar education for a group of students (Bernerth & Aguinis, 2015; Quirmbach et al., 2009). Thereafter, the necessary interventions are administered to the test group, while the control group is not given any form of treatment. In the end, the two groups are tested again to observe the changes they have undergone (Becker et al., 2015).

The control (comparative) group design emphasizes comparing the final posttest results between the test group and the control (comparative) group for exposing the effectiveness of a treatment or intervention (Quirmbach et al., 2009; Yin & Campbell, 2018). The comparison of pretest scores between the two groups is also crucial for confirming if the selection of participants through randomization was effective and that the treatment or intervention introduced in the study was the main source of final result variations between the two groups (Yin & Campbell, 2018). The two-group control design is an exceptionally useful research method because it helps a researcher in noticing the changes between pretest and posttest in a test group and also in comparing the results to those of the control (comparative) group (Bernerth & Aguinis, 2015).

In this study of game-based learning the control (comparative) group design is applicable by making the group of 40 students, who were given the typical instructions, the control (comparative) group and the other group, who were given game-based instructions, the test group. Thereafter, the participants in the control (comparative) group are tested prior to the exercise to confirm that, indeed, their selection from the population was randomized. Similarly, the participants in the test group are pretested to ensure their selection was also unbiased. The analysis of the posttest results is then completed with the aim of comparing the differences in results between the group that was given game-based instructions (test group) and that which was given typical instructions (control group). The discussion is then based on whether the performance of the test group was enhanced by the availability of game-based instructions. The control group design is the best way of carrying out experiments, as it overcomes the limitations of the pretest, posttest design and considers the performance of the control (comparative) and test groups before and after the experiment (Quirmbach et al., 2009).

Independent T-Test

The independent t-test is a statistical method used to test differences between two means (Barde & Barde, 2012). The independent t-test is based on a comparison of two different unrelated groups. Within a t-test one dependent variable is measured at the continuous level, for example, exam performance (Howell, 2010). One independent variable consists of two categorical, independent groups (Howell, 2010). The means for the dependent variable in each of the two groups is compared to determine statistical significance. This method is widely used among researchers to determine if statistical evidence supports differences in the population mean (Carter, 2013). The independent t-test provided the statistical comparison of the comparative group and the experiential group in this study.

This study used a quasi-experimental design. True randomization was not possible in a public-school setting, as students could not be displaced from their classes and curriculum assignments. Control group and pretest, posttest design was utilized. Two fourth-grade classes participated in a control (comparative) group and two participated in an experimental (experiential) group. Dreambox Learning provided the treatment for the experimental (experiential) group. The independent t-test statistical analysis was used to compare the means of the two groups. The sample size from this study may be too small for generalization in larger populations. Achievement of this group may not fully represent the achievements of other groups. More wide scale research should follow this study to increase generalizability.

Dreambox Learning

Dreambox Learning represents the game-based treatment in this study of game-based learning and its effects on low-income learners. According to researchers, there are three main goals in developing an academically productive game system (Adachi & Willoughby, 2013). The goal of developing a game-based learning platform is to ensure the success of every student who interacts with the game (Chisholm & Kingstone, 2015). Secondly, this platform should enable each student to learn at his or her own pace and individualize the level of achievement (Hudson, 2015). Third, this platform should be able to support teachers dealing with a diverse group of students in a classroom environment (Trust, 2017). Essentially, the platform should assist in the differentiation of students at different points on their learning trajectory (Adachi & Willoughby, 2013).

Dreambox Learning is a software that assists students in learning at the elementary school and middle school levels. It focuses on aiding in teaching mathematics through games, animated adventures, and challenges, which help the students to remain engaged in the learning process (Piontek, 2013). In its latest development in 2016, the mathematics curriculum, targeting kindergarten through eighth grade (K-8) students, has been upgraded to support the creation of custom and individualized assignments for individual students. Dreambox Learning fits the definition of advanced web-based educational systems that are anchored on artificial intelligence (AI) technology (Piontek, 2013).

Dreambox Learning is based on the intelligence adaptive learning engine platform, which simulates the learning experience obtained by having a teacher as the learning facilitator (Hudson, 2012). By definition, this software architecture is both intelligent and adaptive. The intelligent component of the software suggested that it is able to emulate human instruction. The activities on which intelligence is based include coaching of students and diagnosing of misconceptions (Jacobs, 2015). Dreambox Learning has been structured to coach students in acquiring mathematical skills. In addition, the software can help diagnose the misconceptions of an individual student in mathematical concepts and thus structure the activities to address and correct those misconceptions (Piontek, 2013).

The Dreambox Learning systems’ ability to identify the skill level of a student and tailor activities based on these skill levels increases learning opportunities (Piontek, 2013). In addition, Dreambox Learning is adaptive because its stages build a model of preferences, goals, and knowledge that are individualized to a student’s needs (Jacobs, 2015). The adaptive component in the learning engine is able to capture the decisions made by the students based on the mastery in specific mathematical skills (Grams, 2018).

Once the initial learning objectives have been identified and achieved, Dreambox Learning can create new learning objectives that advance the acquisition of new mathematical skills (Grams, 2018). This process is progressive and allows the students to develop mathematical skills appropriate to their developmental levels (Bagheri, 2015). Ultimately, the learning engine is able to alter the educational path of each student to ensure maximum acquisition of mathematical skills and mastery as well (Hudson, 2012).

Features and performance. Dreambox learning has numerous features aimed at making the learning experience interactive, enjoyable, engaging, and beneficial (Bagheri, 2015). For example, to reward students, the software has incorporated coins and badges. It has also incorporated mini-games that are unlockable and thus accessible, as the student develops proficiency in mathematical skills (Grams, 2018). This diversity in lessons provides a rich pool of learning resources that students, teachers, and educational administrators can employ at their own convenience (Piontek, 2013).

According to a study performed at Harvard University by the Center for Education Policy Research, the adaptive learning executed by Dreambox Learning was found to have a positive correlation to the improvement in test scores (Mathewson, 2016). The software has a positive impact on the learning process, a feature that has been noticed by many reputable organizations. This software has received many accolades and awards that date back to 2009, just three years after it was first developed (Grams, 2018). The most notable include the Parent's Choice Gold Award, the Tech and Learning award of excellence and the Golden Lamp Award for technology innovation in 2009. In 2010, it was awarded the BESSIE award for Best Elementary Website. In 2012, it was awarded with the Seal of Approval from the National Parenting Center. In 2013, it won two CODiE awards, namely the best Mathematics Instructional Solution award and the best Personalized Learning Solution award (Oliver et al., 2015).

Dreambox Learning recommends completing five to eight lessons every week. Harvard researchers noted marked improvement for students who spent as little as 14-minute sessions in the program (Fullerton & Hughes, 2016). Dreambox Learning has shown improvements in students' standardized test scores and in merging achievement gaps (Matthewson, 2016). It has substantial research that support its credentials as an applicable system in game-based learning (Fullerton, & Hughes, 2016).

Test of Mathematical Abilities

The mathematical ability test, abbreviated as TOMA-3, encompasses five different tests. The tests involved include word problems, symbols and concepts of mathematics, mathematics' attitude, computation and, finally, mathematics in daily life. The aforementioned tests are administered easily and are norm-referenced (Sevecke, 2015). Thus, it is a tool for assessment that identifies, describes, and quantifies deficits in mathematics for school-aged children (Brown, Cronin, & Bryant, 2012). In the research utilizing this test, the obtained normative data was from a sample that was demographically represented in the year 2011 for the United States' school-age population (Brown et al., 2012).

There is no floor and/or effects of ceiling in the composite score. The computation of reliability coefficients by age and subgroup in the given range of a normative sample has been achieved (for instance, gifted and talented American Indians, Whites, Black/African Americans, disability in learning mathematics, and many other subgroups; Sevecke, 2015). Similar computations have also been done for entire normative samples. There have been provisions of several validity studies inclusive of specificity, RouEd (ROU), Area Under the Curve (AUC), and sensitivity. There are only four core subtests with a single supplemental in the TOMA-3. The combination of subtests result from the overall Mathematical Ability Index.

Multiple choice questions are presented to students. These are mathematical-language based questions with signs and symbols, phrases or words used in mathematics. Students provide solutions to problems and they provide solutions to word multiple choice questions involving mathematics in daily life events as well. As the students solve each problem, the difficulty of the word problems increase.

The expression of students' attitude on mathematics is assessed in the supplemental survey on the attitude toward math. The students' self-perceived abilities and achievements toward mathematics are examined in this survey. The survey does not assess any academic math (Sevecke, 2015).

There are four choices for each statement (*No, definitely*; *Yes, definitely*; *closer to No*; and, *closer to Yes*) and a student is allowed to choose only one. The population of 1,456 students, at the most 18 years of age and residents of 21 different states normed the TOMA-3. The reliability of the test is high: scorers' coefficients, content, and time are consistently high. The test also has a high validity in prediction criterion, description of the content, and identification of construct. There is strong support justifying TOMA-3 as a valid research measure (Brown et al., 2012).

Synthesis of Previous Research

Game-based learning acts as a potentially useful tool for teaching mathematics to specific populations, including elementary learners from low-income backgrounds (Ke et al., 2016). One of the possible solutions to improving students' self-confidence, learning performance, and learning motivation is to embed games into math learning activities (Hsieh, Lin, & Hou, 2016). The bulk of the literature indicated significant cognitive gains brought about by games compared to traditional teaching approaches (Fengfeng, 2008; Hsieh et al., 2016; Shin et al., 2012). The studies link game-based learning to aspects such as students' motivation, engagement, learning outcomes, and attitudes to learning (Fengfeng, 2008; Hsieh et al., 2016; Shin et al., 2012). Some studies show significant increases and others show minimal increases. Quantitative, qualitative, and mixed method were utilized in investigating game-based learning. There is a particular mismatch between outcomes from traditional instruction and those facilitated by computer games (Kebritchi et al., 2010; Shin et al., 2012; Ya-Ting, 2012).

The majority of empirical researchers establish that computer assisted instruction, in a focus on game-based learning, constitutes a highly effective instructional tool that enhances students' motivation and achievement (Fengfeng, 2008; Hsieh et al., 2016; Kebritchi et al., 2010;

Shin et al., 2012; Ya-Ting, 2012). Games provide a platform for students to learn a host of skills, including problem-solving, creativity, and critical thinking (Simões, Redondo, & Vilas, 2013). Instantaneous feedback constitutes one of the most powerful attributes of computer games, given that it motivates students to stick with learning the content by offering a rewarding and engaging environment (Ronimus et al., 2014).

Studies by various researches consistently highlight that game-based learning can positively impact aspects such as student motivation and engagement (Eseryel et al., 2014; Hamari et al., 2016). Once motivation and engagement are impacted then mathematical knowledge is acquired (Jabbar & Felicia, 2015). Game-based learning yields to significantly better attitudes toward learning, which in turn enhances mathematics achievement among elementary students (Fengfeng, 2008; Hsieh et al., 2016; Kebritchi et al., 2010; Shin et al., 2012; Ya-Ting, 2012).

Student social economic status is a well-known demographic factor that strongly influences student achievement in mathematics (Degol, & Bachman, 2015; Lee, 2012). Studies have shown increased performance and achievement among elementary school learners through the use of computer games (Jitendra, Griffin, & Xin, 2010). Games were proven highly effective in enhancing the learning and enjoyment of mathematics (Kim & Chang, 2010). Learning mathematics through games was active, adventurous, and investigative (Mazza, 2015). Interactive immersive games help in consuming children's attention for hours, while simultaneously offering effective instruction and engaging the learning experience (Park & Yun, 2018; Reeve & Lee, 2014; Sabourin, & Lester, 2014).

Some of the areas that games can be employed to foster students' mathematics achievement include algebra skills, problem-solving, arithmetic procedures, strategic and reasoning abilities, and critical geometry (Divjak & Tomic, 2011; Jeng-Chung, 2014; Sengupta-Irving & Enyedy, 2014; Weigel, 2013). Games have shown positive effects for student scholarship (Carr, 2012; Clark, 2014). The game-based learning environment is an environment conducive to student learning, motivation, confidence, and achievement (Jong, 2015; Ku et al., 2014; Lee, 2012; Mustafa et al., 2011).

Critique of Research Findings

The research findings were multifaceted in methods and design. Studies explored the effect of game-based learning on students' motivation, engagement, confidence, and achievement (Fengfeng, 2008; Hsieh et al., 2016; Kebritchi et al., 2010; Liu & Chen, 2013; Shin et al., 2012; Ya-Ting, 2012). Researchers measured a game-based environment and its potential to impact students' outcomes. Game-based learning amplified student motivation, engagement, and confidence and, subsequently, improved student achievement (Maclellan, 2013; Villalon, 2016).

Motivation is a documented key factor for all learning activities. Kebritchi and colleagues (2010) immersed students in digital three-dimensional games to increase student motivation. Findings uncovered that students were not only motivated, but also knowledge was transferred into real-world application. Student motivation is increased—by game-based learning's immediate praise and elicitation of learner curiosity—through interacting in the games (Ya-Ting, 2012). These investigations proposed that one of the significant effects of game-based learning was motivation (Kebritchi et al., 2010; Ya-Ting, 2012).

Case studies revealed student engagement and confidence to be highly impacted in game-based environments. Hsieh and colleagues (2016) measured student facial expressions as well as non-verbal behaviors and found consistent increases in engagement. Game-based learning increased students’ confidence in mathematics using the confidence sub-scale of the Fennema-Sherman to measure mathematics attitudes. Game-based learning cultivates confidence and engagement (Ku et al., 2014).

Research supported game-based learning as a catalyst for achievement (Su & Cheng, 2014). Digital and non-digital games operate as sources for improving learning outcomes (Tanes & Cho, 2013). The games improve a student’s arithmetic skills (Shin et al., 2012). Hands-on games develop the students’ knowledge of calculation concepts such as mode and mean (Dieser & Bogner, 2015; Mittag, Taylor, Fies, Johnson, & Dogbey, 2010). Zhang (2015), however, found that games, absent of curriculum objectives, do not always cultivate achievement. Students when given the liberty to explore online games without directives do not improve in math (Zhang, 2015). Game-based learning is best served through strategic curriculum-based games (Zhang, 2015). Literature repeatedly acknowledged student academic competence as a result of game-based learning (Williams et al., 2018).

Literature clearly supported the use of game-based learning to cultivate student motivation, engagement, confidence, and achievement (Hsieh et al., 2016; Kebritchi et al., 2010; Mustafa et al., 2011; Ya-Ting, 2012). A thorough search of the literature investigating the effects of game-based learning on low-income students’ math achievement established a need for further research on effects of game-based the learning on low-income Title 1 learners (Lee, 2012). The majority of the literature affirms that a game-based environment positively impacts learner outcomes (Hsieh et al., 2016; Kebritchi et al., 2010; Mustafa et al., 2011; Shin et al., 2012; Ya-Ting, 2012).

Summary

Game-based learning, with its roots in constructivism and flow theory, productively supplements math curriculum (Sharek & Wiebe, 2011). Constructivism emphasizes learning by doing, and flow theory is a state of complete focus and attention to a task (Ke et al., 2016; Kim et al., 2016; Mayer et al., 2013). These theoretical foundations provide a basis for understanding the effects that games have on student learning (Ertmer & Newby, 2013; Sharek & Wiebe, 2011). However, research such as that of Zhang (2015) supported the proposition that the games can be ineffective, unless they embrace a strategic learning objective. Predominate research suggested a positive correlation between a game-based environment and student learning outcomes (Eseryel et al., 2014; Hung et al., 2014; Woo, 2014).

There is limited research on game-based learning and its relationship to the low socio-economic learner (Berger & Archer, 2015; Hsin et al., 2014; Lee, 2012; Vrgute et al., 2015). The low socio-economic learner represents a large percentage of the nation's learners (Reardon, 2013). This study extended game-based research. The documented gap in math achievement between the low-income learner and the more affluent learner yields opportunity for further game-based research. These identified themes and gaps in the literature guided the current study.

Examined in the literature review was the impact of a game-based learning environment on student motivation, engagement, confidence, and achievement, as described in studies by researchers, such as Kebritchi et al. (2010), Ku et al. (2014), and Ya-Ting (2012). Reviewed in the following chapter is the methodology for the research study designed to examine the effects of game-based learning on achievement for students from low-income families. Described is the research question and hypotheses. A detailed explanation of the research design and sampling method is provided. Reviewed are data collection procedures and methods of analysis.

Chapter 3: Methodology

Game-based learning has been shown to have positive achievement outcomes in math for learners (Hung et al., 2012; Eseryel et al., 2014; Woo, 2014). It has been successfully adopted to improve math scores among general students and can also be used to benefit low-income students (Mustafa et al., 2011; Shin et al., 2012). Game-based intervention is necessary for low-income students, as the students in the bottom quintile of family socioeconomic status consistently score more than a standard deviation below those in the top quintile on standardized tests in math when they enter kindergarten (Dickinson & Jill, 2014; Reardon, 2013).

The primary intention was to investigate the effects of game-based learning on Title 1 elementary student's math achievement. The game-based approach was explored as an alternative curriculum support for minimizing the achievement gap of fourth-grade Title 1 learners in mathematics. Lastly, the intention was to add to the limited literature on game-based learning for elementary and Title 1 students in mathematics.

This study was designed to add to the research in game-based learning by extending it to fourth-grade Title 1 elementary learners. Mathematical achievement is not consistent across socio-economic representation in classrooms (Berger & Archer, 2015). Although the literature has addressed game-based learning for student math achievement, few studies have specifically addressed low-income learners (Berger & Archer, 2015; Hsin et al., 2014; Lee, 2012; Vrgute et al., 2015). The gap in the literature was addressed by this investigation.

Presented in the chapter are the research procedures that were utilized in the study. The first section of the chapter presents a brief overview of the study purpose, research questions, and hypotheses. Following the hypothesis is a discussion of the research design, target population, and sampling procedures. Additionally discussed are the instrumentation, data collection procedures and operationalization of variables, data analysis procedures, limitations, and delimitations of the study. The limitations are followed by a discussion on the internal and external validity of the study, expected findings, and the ethical considerations that were observed during the study. The chapter is summarized in the last section.

Purpose of the Study

The purpose of this study was to investigate the effects of game-based learning on Title 1 elementary students' math achievement. Explored was the game-based approach as an alternative curriculum support for minimizing the achievement gap of fourth-grade Title 1 learners in mathematics. Lastly, this study added to the limited literature on game-based learning for elementary and Title 1 students in mathematics.

Research Questions and Hypotheses

The study was guided by the following research: What are the effects of a game-based learning supplemental instruction on the math achievement of Title 1 students? The following hypotheses were tested to answer the research question:

$H_0 1$: There is no effect for game-based learning instruction on fourth-grade Title 1 learners' achievement in recognizing signs and symbols related to mathematics.

$H_0 2$: There is no effect for game-based learning instruction on fourth-grade Title 1 learners' achievement in mathematical computation.

$H_0 3$: There is no effect for game-based learning instruction on fourth-grade Title 1 learners' achievement in understanding everyday life mathematics.

$H_0 4$: There is no effect for game-based learning instruction on fourth-grade Title 1 learners' achievement in mathematical word problem solving.

H_05: There is no effect for game-based learning instruction on fourth-grade Title 1 learners' attitude toward mathematics

Research Design

Quantitative research methods were used for this study. This technique focuses on expressing research phenomenon numerically and investigates the degree of homogeneity as to characteristics of the study population (Claydon, 2015). Second, this method involves rigorous examination of data using simulation, inferential, and experimental methods for determining the relationship between research variables (Labaree, 2009; Oliver, 2010). Third, the research method sought to maintain objectivity through statistical, mathematical, or numerical analysis of the collected data. Alternatively, manipulation of pre-existing statistical data using computational techniques sufficed (Watson, 2015). Then, the technique, essentially deductive in nature, enhanced statistical analysis through impartiality of the conclusions that were drawn from the research findings (Dania & Zounhia, 2016).

Lastly, numerical data collected during quantitative studies is analyzed in terms of descriptive statistics, such as frequency, percentages, spread (range and standard deviation), and inferential statistics (Hoe & Hoare, 2013). Inferential statistics enables researchers to determine the statistical significance of a variable (Creswell, 2009). Quantitative researchers are able to draw inferences from the data and generalize their findings across the study population. Quantitative research was most suitable for the study because it allowed the researcher to investigate the relationship between game-based learning and math achievement of fourth-grade Title 1 learners.

Specifically, a quasi-experimental research design was used for the study. Quasi-experimental design compares an experiential group to a comparative group, where full randomization was not possible (Shadish, & Galindo, 2010). It would be difficult to choose students in a public-school setting at random and place them in specific groups and classes; thus, quasi-experimental design was the best design for this study. Quasi-experimental design involves manipulation of variables with the aim of observing their effects on other variables (Thayer, 2012). It also entails intentional introduction of treatments, procedures, or programs for observing the results or outcomes (Oliver, 2010).

True experiments are characterized by four key elements: manipulation, control, random assignment, and random selection (Campbell & Stanley, 2015). The elements of manipulation and control are the most essential in quasi-experimental studies (Shadish, & Galindo, 2010). Importantly, manipulation involves the introduction of intervention/treatment, while control adopts measures to prevent external factors from affecting the study outcomes (Levy & Ellis, 2011). In quasi-experimental studies, participants are assigned to the experiential and the comparative groups, followed by evaluation of the outcomes of the adopted intervention (Campbell, & Stanley, 2015).

Two of the most adopted types of quasi-experimental research are the pretest and posttests with control (comparative) group design (Quirmbach et al., 2009). This design is commonly preferred as it facilitates control over threats to internal validity (Zientek et al., 2016). Participants are assigned to two groups: the experimental (experiential) group (Group A), which undergoes the treatment/intervention, and the control (comparative) group (Group B), which is not subjected to any conditioning. The control (comparative) group serves as the benchmark in comparison (Levy & Ellis, 2011). In this design, the researcher performed two distinct measures, the pretests and the posttests for the two groups. The researcher used the posttests to gain evidence of a valid implication of the intervention in the experimental (experiential) group (Levy & Ellis, 2011).

Both the pre-test and posttest techniques, alongside a control (comparative) group quasi-experimental design, were adopted for this study. In particular, four low-income Title 1 fourth-grade classes were targeted. The classes were located in Title 1 schools and the principals provided the researcher with data regarding low-income percentages of students in a class. Two classes were assigned to the experiential group, with the remaining two serving as the comparative group.

The Test of Mathematical Ability TOMA-3 pretest was administered to all the classes. TOMA-3 included five tests: mathematical symbols and concepts, computations, word problems, mathematics in everyday life, and attitude toward mathematics. These parameters were used to calculate the Mathematical Ability Index, which embodies a wide range of numerical abilities (Brown et al., 2012). The experiential group was then exposed to a seven week game-based learning environment through the research-based computer game system, Dreambox. After the seven week period, the TOMA-3 posttest was then administered to all the classes to establish the difference in mathematical achievement between the experiential group and the comparative group. Thus, the quasi-experimental research design was appropriate for this study, as it helped provide valid evidence on the effects of game-based learning on mathematics achievement among fourth-grade Title 1 elementary students.

Target Population

A study population refers to the aggregate subjects in a study, who have the characteristics or inclusion criteria that are outlined by the researcher (Babbie, 2008). The population in this study was the fourth-grade Title 1 learners. Specifically targeted for the study were fourth-grade learners, attending a Title 1 district in the southern region of the U.S. The district was a Title 1 district, meaning all schools within this district are Title 1 schools. Within the district, 82% of the students are economically disadvantaged, and over 71% of students are considered at risk. The district serves an almost entirely Hispanic and African American population—71% Hispanic and 24% African American with a 95% attendance rate.

Title 1 schools are those that benefit from the 1965 Elementary and Secondary Education Act (ESEA). The ESEA legislation set the guidelines for school district federal, funding for school districts and schools with high numbers of needy students. The Title 1 program is the fourth largest federal program for low-income children. Notably, this program has been implemented in over half the public schools in the country and benefits approximately 17 million students (Weinstein, Stiefel, Schwartz, & Chalico, 2009). The targeted Title 1 campus selected from this district serves mostly fourth- grade of which 95% of the fourth- grade population is considered economically disadvantaged and at risk.

Sampling Method

As it is not possible to involve all the subjects of a study population in the research process, researchers use subsets of the study population for drawing inferences in relation to the research phenomenon (Babbie, 2008). This is achieved through sampling, which is the process of choosing an appropriate subset to represent the study population. The appropriate sample size for this study was determined using power analysis. This technique is an important aspect of experimental studies, as it is mostly used to estimate the sample size. This method assists researchers to determine a suitable sample size that adequately represents the target population.

The obtained sample size enables researchers to approximate the degree of an effect that can be noticed with a specific sample size (McDonald, 2009). For this study, the sample size needed for this experiment was determined through the use of the G*Power software. The computation through the use of G*Power software indicated a required sample size of 80. Thus, the experiential group consisted of 40 students and the comparative group accommodated the remaining portion.

Intervention

Four fourth-grade classes made up of 20 students participated in the study. Two classes were assigned to the experiential group, whereas the remaining two made up the comparative group. Each group was made up of 40 students. Student names and identities were concealed through codes and pseudonyms. There were six general education fourth-grade classes in the participating schools. Two classes belonged to the researcher; so as to maintain ethical objectivity, the other four classes participated in the study. The experiential and comparative groups in the four classes were unsystematically selected.

Classroom instruction was the same for all participants. Teachers followed the same curriculum guidelines throughout fourth-grade. The game-based intervention differentiated the experiential group from the comparative group. Treatment took place during the students' normal out-of-class specials times for at least 45 minutes weekly. This study continued for a total of seven weeks, as the predicted eight weeks were not available. The primary data was collected through the TOMA-3 test, administered by certified teacher volunteers during each class's specials time. These volunteer teachers were trained by the researcher to administer TOMA-3. Teacher volunteers assigned student identity codes, but the researcher calculated student pre- and posttest scores for consistency. The TOMA-3 test facilitated the evaluation of the students' mathematical abilities.

The students were required to take the TOMA-3 test before the experiential group was exposed to a game-based learning environment (pretest) and after the group was exposed to the environment (posttest). The process enabled the researcher to compare the effect of the game-learning environment on the students' math capabilities. The primary data was the most appropriate for this study.

Instrumentation

Instrumentation includes data collection tools that were adopted in a study. The research design in a study determines the data collection tools suitable for a particular study. Researchers are encouraged to adopt tools that can assist them in achieving the research objectives (Mertens, 2010). Data collection tools range from self-developed surveys, interviews, case studies, and observations among others. It is crucial to note that different instrumentation methods have diverse strengths and limitations. Thus, researchers should adopt published and peer-reviewed research instruments.

In this study, pretests and posttests were adopted from a published instrument, known as the Test of Mathematical Ability (TOMA-3). As a supplement, the TOMA-3 also offers an attitude toward math assessment test, which is norm-referenced and easy to administer and was used in identifying, describing, and quantifying mathematical attitudes among learners. The TOMA-3 was tested for reliability through three types of correlation coefficients: coefficient alpha, test-retest, and scorer difference (Brown et al., 2012). The coefficient alpha demonstrates the extent to which test items correlate with one another. The averaged coefficient for the mathematical ability index is .96, a value indicating nearly perfect reliability (Brown et al., 2012). The test-retest method examines test performance consistency. The correlated standard scores mostly exceeded .80, which supported little sample error occurred within the test. The scorer difference coefficient exceeded .90, providing strong evidence supporting test scorer reliability.

The TOMA-3 was also tested for validity. Correlations with mathematical ability measures were .50 (large) to .92 (very large). The standard deviations, standard score means, and comparative data were analyzed. The statistical results supported the TOMA-3 as a valid mathematical measure (Sevecke, 2015). TOMA-3 was also tested for sensitivity and specificity indexes, which test the ability to identify students with learning disabilities. All reported values regarding the TOMA-3 exceeded high standards and supported TOMA-3 as a valid and reliable assessment (Brown et al., 2012). It is important to note that the TOMA-3 test is an improvement of the original TOMA, and the TOMA-2 tests were developed by Brown, Cronin, and McEntire in 1994. This test can be administered to individuals or among groups; the test takers take about 90 minutes to complete the test (Brown et al, 2012). The TOMA-3 test was used in presenting the results in the form of raw scores, percentile ranks, scaled scores, age/gender equivalents, and the Mathematical Ability Index (Sevecke, 2015).

Several different researchers have adopted the TOMA-3 test or its previous versions for studies. For example, Jitendra and colleagues (2012) used the previous version of the test to evaluate the influence of adherence to the implemented curricula on the mathematical achievement of third grade students. Another study by Chia, Ng, Tan, and Wee (2014) used the TOMA-2 test to compare mathematics learning between American and Singaporean learners. In another study conducted among at-risk students, Lopez (2008) used the TOMA-2 test to evaluate how the learners solved mathematical word problems by employing strategies such as problem-solving and direct instruction. TOMA is among the most commonly adopted tools for evaluating mathematical capabilities and achievement among students. Thus, this tool was suitable for this study.

The students were tested based on four core items and one supplemental item. The core components included mathematical symbols and concepts, computation, mathematics in everyday life, and word problems. The supplemental item defined students' attitude toward mathematics (Brown et al., 2012). Under the mathematical symbols and concepts category, students answered several questions focusing on mathematical signs, symbols, words, or phrases. Each question had four possible answers: A, B, C, and D.

In the computation component, students were required to apply their math skills to solve numerical problems with different difficulty levels. Furthermore, they were provided with a Student Response Booklet, in which they were required to show their solutions (Brown et al., 2012). Under Mathematics in Everyday Life, participants of the study responded to questions related to the use of mathematics in daily life situations. Just as in the first component, the questions had four possible answers. The last component, that is, the word problems required the learners to answer a series of increasingly challenging word problems. They showed their workings and solutions in the Student Response Booklet (Brown et al., 2012).

The supplemental component required the learners to indicate their attitudes toward math instructions and their views regarding their capabilities and achievement in the subject. To achieve this, they were provided with four boxes against questions to indicate *Yes, Definitely*; *Closer to Yes*; *Closer to No,* and *No, Definitely*. The scores from the core components were used to compute the Mathematical Ability Index for the students (Brown et al., 2012).

Data Collection

Researchers use either primary or secondary data. Primary data is the first-hand information that is sourced from study subjects, whereas secondary data is the published information that is obtained from Internet sources, journals, books, periodicals, and company reports, among others (Mertens, 2010). This type of data is collected through diverse research instruments ranging from surveys, questionnaires, and interviews. On the other hand, secondary data is sourced through analysis of the published materials, which provide significant information on the research problem (Johnston, 2017).

The two types of data are associated with various advantages and disadvantages. For example, by using primary data, researchers are able to acquire new insights as to the research phenomenon (Collins, 2010). Additionally, primary data enables researchers to tackle a research problem in a valid and rigorous way. However, collection of primary data is rather involved and time-consuming (Collins, 2010). Conversely, secondary data is easier to collect and enhances the ability to conduct comparative analysis and triangulation (Hair, Celsi, Money, Samouel, & Page, 2011).

In this study, primary data was used to investigate the research problem and achieve the study objectives. The data were collected from the sample of 80 Title 1 students from four fourth-grade classes. As indicated in the sampling section, two classes were randomly assigned to the experiential group, while the remaining two made up the comparative group. Each group was made up of 40 students. The primary data was collected through the TOMA-3 test, which facilitated the evaluation of the students' mathematical abilities. Primary pretest data was collected a week before the seven-week intervention of game-based treatment. Trained volunteer teachers administered the test to whole groups of students during their specials time. The students were required to take the test before the experiential group was exposed to a game-based learning environment (pretest) and again after the seven-week exposure to the game treatment (posttest). Working with this time frame enabled the researcher to compare the effect of the game-learning environment on the students' math capabilities. Primary data was the most appropriate for this study.

Dreambox was utilized for the game-based treatment in this study. The software program, Dreambox, provides students with assistance in learning mathematics through games, animated adventures, and challenges, which help the students to remain engaged in the learning process (Piontek, 2013). The program content is based on the state curriculum standards. When students begin using Dreambox for the first time, they start at a level one half-grade prior to their current grade. Dreambox constantly assesses and quickly determines when a student is ready for advanced concepts and then adjusts to their pacing and comprehension accordingly. Students return to their assessed conceptual level each time they enter the program. The program is progressive and allows the student to develop mathematical skills appropriate for their Dreambox assessed developmental level (Mathewson, 2016).

Operationalization of Variables

Operationalization entails defining the variables that symbolize distinct concepts in a study. This term also infers how the key concepts in a study are measured. Notably, operationalization involves developing measurable representation of the study variables that result in empirical observation of the theoretical concepts. At the same time, it allows researchers to evaluate the conceptual definitions in relation to the reality (Martin, Cohen, & Champion, 2013).

The variables used in the study were classified into two main categories. The independent variable in the study is game-based learning. The variable involves using games to enhance the learning experience (Isaacs, 2015). During the study, the fourth-grade Title 1 learners in the experiential group were exposed to a game-based learning environment so as to evaluate the impact of games on their math achievement. The dependent variable in the study was students' scores on the TOMA-3 test. The experiential group was exposed to the game-based treatment at least an hour and a half per week for seven weeks in addition to traditional instruction. The comparative group was solely exposed to traditional instruction. The dependent variable was measured using the Mathematics Ability Index, through the use of the TOMA-3 test. The game-based independent variable operated to provide a comparison between the experiential and comparative groups. The dependent variable of students' scores was then compared to determine statistical significance.

Data Analysis Procedures

Data analysis involves rigorous scrutiny of the data that are collected during research for answering the research questions and achieving the study objectives. The researcher adopted quantitative data analysis procedures to determine whether there was a significant correlation between game-based learning and student's math achievement. The collected data were analyzed statistically using the Statistical Package for Social Scientists (SPSS, version 25). In particular, the software was used to conduct different appropriate statistical tests.

The researcher used descriptive and inferential statistics to analyze the data. The five subtests available through TOMA-3 were used to test five different hypotheses individually. All 80 students were administered each of the five TOMA-3 assessments as a pretest and again after the seven week period as a posttest. During the seven-week period, the experiential group experienced game-based treatment and traditional instruction while the comparative group only experienced traditional instruction. As previously mentioned, after the seven-week period all students were administered the TOMA- 3 again as a posttest. The independent t-test was run to statistically compare the experiential groups and comparative groups in this study. Specifically, the statistical method was used to test differences between two means (Stigler, 2008). The independent t-test statistic is the ratio of the average variability among groups to the average variability in groups. This method also contributes to the anonymity of the research participants, as means are compared and not specific participant scores.

Limitations and Delimitations of the Research Design

The study focus was restricted to only investigating the effect of game-based learning on the math achievement of fourth-grade Title 1 elementary learners at one school site. Findings, therefore, are not generalizable across other sub-groups of students. Additionally, the mathematical curriculum was based solely on a state in the southern part of the U.S. Therefore, the study findings may not be generalizable to the curricula standards of other states. Although the curriculum is the same for all fourth-grade classes, teachers may have used different strategies that may be a limitation to the study. Attendance of experiential participants may be a limitation if attendance is not consistent. Again, the study was limited to Dreambox, which may hinder the ability to infer meaning beyond the findings based on the employed game. There are also limitations due to the small sample size.

Internal and External Validity

Validity in research refers to the credibility and accuracy of the collected data, and whether the study findings convincingly and expansively answer the research questions or hypotheses (Ellis & Levy, 2009). Internal validity is the extent to which a research study establishes the cause-and-effect relationship between the intervention and the research outcome. In particular, it is founded on a logical process such as the logical framework that is presented by the structure of the research report (Leedy & Ormrod, 2010).

In this study, the internal validity was obtained through the use of both experiential and comparative groups. Internal validity was also maintained through the specified instrumentation in which pretests and posttests were used to evaluate the cause-effect-relationship between game-based learning and math achievement among fourth-grade Title 1 elementary learners. The TOMA-3 test, that was used to determine math achievement among the participants, is a convincing measure of mathematical ability.

The test can be used among learners in the 8-to-18-years age gap from any gender, racial background, income level, and exceptionality status (Brown et al., 2012). This is because the TOMA-3 was normed and stratified using a sample that possessed the identified characteristics. Additionally, the test has a high internal consistency as indicated by a coefficient alpha of 0.90 for all the five components, which indicated a high level of reliability. As aforementioned, the average coefficient for the Mathematical Ability Index is 0.96, which demonstrates nearly perfect reliability. The TOMA-3 has a test-retest co-efficient of over 0.80, indicating that the test has minimal time sampling error, further evidencing the high reliability of the test (Brown et al., 2012). Moreover, the statistical tests that were adopted in the study enhanced the internal validity as the correlation between game-based learning and math achievement was evaluated.

External validity is the extent to which the findings of a study can be generalized and across other populations, settings, and times. In particular, external validity is categorized into population and ecological validities. The population validity is the extent to which findings can be generalized across populations (Johnson & Christensen, 2012). The participants of the study were drawn from four classes in a Title 1 school. Thus, the findings may be generalized across other low-income Title 1 elementary students. However, they may not be generalizable to other student populations. Ecological validity is the degree to which the findings can be generalized across settings (Johnson & Christensen, 2012). The procedures that have been described in the study can be replicated in other settings or among other student populations.

Expected Findings

The expected findings indicated whether game-based learning had a significant positive impact on math achievement of fourth-grade Title 1 learners. Additionally, the results were expected to demonstrate the difference in math scores between the students in a game-based learning environment and those receiving normal instructions. The findings added to the available literature by providing important insights on the effect of game-based learning on low-income students. Also, the study findings provided new knowledge by demonstrating the effects of game-oriented instruction on mathematical achievement of fourth-grade learners in Title 1 schools.

Ethical Issues

Researchers are required to observe different principles of ethics, while conducting studies that involve human participants. In this study, different ethical standards were observed while conducting the study. These included the principle of respect for the rights of the participants and their dignity. Essentially, this principle urges researchers to protect the participants' rights as to self-determination, confidentiality, and privacy (Creswell, 2009). This study utilized summary archived data without names attached. Statistical tests such as independent t-tests provided the researcher with the necessary percentage data needed to dissect the effect of game-based learning. The researcher did not need student names.

Permission was obtained from the district to perform the study. The research took place on the school campus. The district provided its own consent procedures and released the archived data to the researcher. The researcher did not collect students' identification details. Thus, they were given a code or pseudonym that was used during the tests. Additionally, hard copies of the collected data were stored in a locked drawer, while copies of the electronic data were kept in a password-protected computer that was only accessible to the researcher. Information connecting the names and codes were kept in a separate file and in a locked cabinet. After the end of the study period, the hard copies were shredded, whereas the electronic data was deleted.

Summary

Presented in the chapter are the methodological procedures that were adopted for the proposed quantitative study. Specifically, a pretest and posttest alongside a comparative group experiential research design was employed. The population of interest made up of fourth-grade learners from a selected Title 1 school. Eighty students were sampled from four fourth-grade classes in the school. The classes were assigned to the experiential and the comparative group. Primary data was collected using the TOMA-3 test, and it was analyzed using descriptive and inferential statistics.

Presented in the chapter are the limitations and de-limitations of the study. For example, the study was limited to fourth grade Title 1 elementary learners; hence, hindering generalization of the findings to other student populations. Also, presented were the measures that were adopted to ensure internal and external validity and the reliability of the TOMA-3 test has also been discussed in detail. Study findings are covered in the next chapter. Findings were expected to indicate whether game-based learning had a significant positive impact on math achievement of fourth-grade Title 1elementary learners, and if there was a difference between math achievement of learners exposed to a game-based learning environment and those under general instructions. During the study, the researcher upheld different principles of ethics in research. Presented in the next chapter are the analysis of the data and the study findings.

Chapter 4: Results and Analysis

The purpose of this quasi-experimental study was to investigate the effects of game-based learning on the math achievement of fourth graders attending a high poverty Title 1 school. Eighty fourth graders were selected to participate in the study. Students were divided into two separate groups, the experiential group and the comparative group. The experiential group participated in a seven-week intervention treatment using the Dreambox program as the game-based learning strategy. Students in the comparative group received traditional review instruction in math. Prior to the intervention and after the treatment, the Test of Mathematical Ability (TOMA-3) was used to assess student learning in math skills for both comparative and experiential groups, TOMA-3 consisted of five subtests. Subtests included recognition of signs and symbols, mathematical computation, math in everyday life, word problem solving, and an attitude toward the mathematics supplemental test.

All the 80 participating students completed the TOMA-3 pretest. After the pretest, the experiential group consisting of 40 students was exposed to a seven-week game-based intervention. Once the intervention period was completed, both the comparative group and the experiential group were administered the TOMA-3 posttest. Data from the TOMA-3 test was collected and analyzed using an independent t-test for the two groups of fourth-grade students, the experiential group receiving the treatment and the comparative group. The data were collected and then analyzed to determine the effects of game-based learning on fourth-grade students attending a Title 1 school.

Chapter 4 includes the findings from the quasi-experimental game-based research. Included is a description of the sample and summary of results. Tables and charts along with a detailed statistical analysis are included for each hypothesis. The findings presented in this chapter represent the results of the study on game-based learning and its effect on fourth-grade Title 1 learners.

Description of Sample

The study included 80 participants (37 boys and 43 girls) from the Hispanic and African American populations. The elementary school study site had an enrollment of 823 students; and, out of those, 732 were considered at risk and/or economically disadvantaged. The fourth-grade constituted the largest group of students in school. Of the 164 students in the fourth-grade, 159 were considered general education students. Thirty-one of the fourth grade students were bilingual. This study focused on students without bilingual, ESL, special education services, or accommodations. Of the fourth grade students, 95% was considered economically disadvantaged and at risk. Table 1 contains a summary of the demographics data for the study sample.

Table 1

Demographics of Sample

Group	Control	Experimental	Total
Hispanic	25	23	48
African American	15	17	32
Male	19	18	37

Summary of Results

Five hypotheses were tested for the study. The fifth hypothesis was supplementary. These five hypotheses were associated with math abilities and tested to determine if the mean scores of students who received the game-based treatment differed from those who did not. The following lists the research question with its corresponding hypotheses.

RQ. What are the effects of a game-based learning supplemental instruction on the math achievement of Title 1 students?

$H_0$1 There is no effect for game-based learning instruction on fourth-grade Title 1 learners' achievement in recognizing signs and symbols related to mathematics.

$H_0$2 There is no effect for game-based learning instruction on fourth-grade Title 1 learners' achievement in mathematical computation.

$H_0$3 There is no effect for game-based learning instruction on fourth-grade Title 1 learners' achievement in understanding everyday life mathematics.

$H_0$4 There is no effect for game-based learning instruction on fourth-grade Title 1 learners' achievement in mathematical word problem solving.

$H_0$5 There is no effect for game-based learning instruction on fourth-grade Title 1 learners' attitude toward mathematics

A *p*-value less than .05 or $p < .05$ was sought for significance. An independent t-test was run on each of the subtests to compare the means for the two groups, the experiential and the comparative groups. Independent t-tests compare known averages in various data sets (Howell, 2010). These averages or means are used in pre- and posttest research to determine if there is a significant difference between the means. The analysis of results contained the test results for the assumptions of normality, outliers, homogeneity, descriptive statistics, and findings from the independent t-test analysis for each of the subtests.

Independent T-Test Terminologies

- Robust statistics: Statistical measures on which extreme observations that are not representative of the true data have little effect, such as the Wilcoxon Test. Robust statistics have good performance with distributions that are not normal. Robust statistics perform effectively, while its variables or assumptions are altered (Wilcox, 2012). However, the tests are less powerful because the data are ranked.
- Independent variable: The predictor or experimental variable that is being manipulated to observe its effect on the outcome. An independent variable variation does not depend on other variables (Kirk, 2013).
- Continuous variable: A variable has a continual number of possible values. Examples of continuous variables include height, salary, time, or as in this study, test scores (Kirk, 2013).
- Dependent variable: A variable whose value is dependent on the independent variable. The dependent variable is considered the outcome variable (Kirk, 2013).
- Independence of observations: There is no relationship between the observations in each group of the independent variables or between the participants in any of the groups (Kirk, 2013).
- Gain scores: The improvement in scores from pretest to posttest. Gain scores are calculated by computing the difference between the pre- and posttest scores (Kelley et al., 2016).

The independent t-test is considered robust. With equal sized groups, results are minimally affected by violations of assumptions of normality and violation of homogeneity (Courtney & Chang, 2018). The assumptions for independent t-tests were assessed, which include the presence of one dependent continuous variable, one independent variable that consists of two or more categorical, independent groups, independence of observations, homogeneity or equality of variances, and the normal distribution of the residuals or the normality.

The independent t-test requires one dependent variable that is measured at the continuous level. In this study, that dependent variable was the student scores on the TOMA-3. The second prerequisite was one independent variable that consisted of two or more categorical independent groups. The two categorical groups in this study were the experiential and comparative groups. Third, there must be independence of observations, which means there is no relationship between the participants in any of the groups. This study met this assumption by simply making sure students were only in one group. The prerequisite assumptions for all data sets were met in each of the subtests. Three independent t-test assumptions were statistically tested for each of the subtests. Within the statistically tested assumptions there were no statistically significant outliers and the dependent variables were normally distributed. In addition, there was homogeneity of variances.

Outliers-Boxplots

Outliers are unusual scores that are either extremely small or exceptionally big in any group of data (Sweet & Martin, 2012). Outliers have the potential to change the significance of a study. Outliers negatively affect the independent t-test by reducing the validity of results (Kang & Harring, 2012). However, a statistical outlier does not always effect statistical significance (Myers, Well, & Lorch, 2010). Researchers address outliers differently, including dropping the outlier, keeping the outlier, transforming the outlier, or modifying the outlier (Sweet & Martin, 2012). SPSS boxplots were used in this study to test for outliers. These plots identified participant scores that were different from the range of the other participant scores. Figure 1 illustrates how outliers are identified.

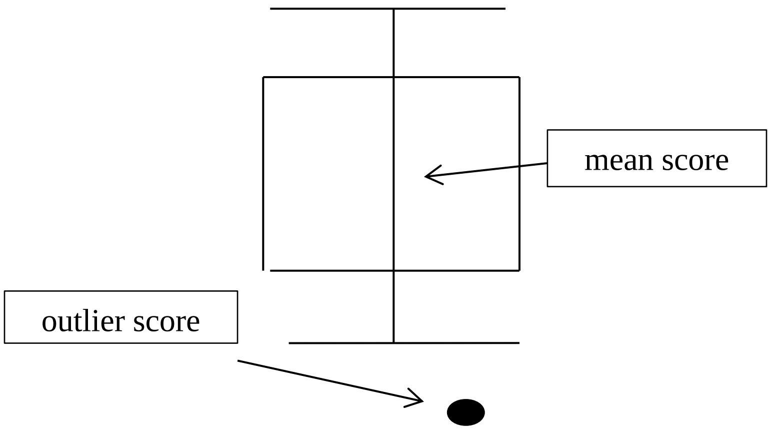

Figure 1. Boxplot with outlier score.

Four of the five subtests met the assumption of no outliers. In Subtest 1, there was an outlier. Although the data results in the study sustained significance, the results for Subtest 1 did not have as much statistical power as the other subtests that met the assumption.

Normality-Shapiro-Wilk

Normality represents normal distributions in the data. Statistically, data such as scores fall within a particular range. A normally distributed population will have an equal mean, median, and mode. Figure 2 represents a normal distribution known as a bell curve.

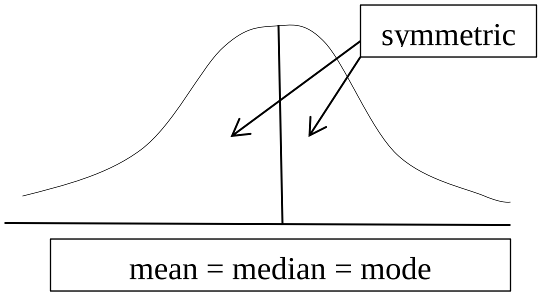

Figure 2. Normally distributed data curve.

In the independent t-test, the Shapiro-Wilk is used to test normality. The Shapiro-Wilk test of normality demonstrates normality of distribution. When the Shapiro-Wilk significance is greater than .05, there is a normal distribution. Four of the subtests in this study met the assumption of normality. However, in Subtest 1, there was an outlier causing the assumption normality to not be met. The independent t-test statistical method is considered robust with equal sized groups, meaning results are minimally affected by violations of assumptions of normality and violation of homogeneity (Myers et al., 2010). The results for Subtest 1 did not have the same statistical power of the other subtests that met the assumption.

Homogeneity-Levene's

The Levene's test of homogeneity was run to satisfy the independent t-test assumption of homogeneity of variances. Homogeneity suggests that two populations come from the same distribution. Homogeneity is met when the Levene's value is greater than .05. In this particular study three of the five subtests met homogeneity. However, Subtest 3 and the supplemental attitude toward mathematics subtest did not meet the assumption of homogeneity. It should be noted that when the groups are of equal sizes, as in this study, a violation of this assumption does not invalidate results (Howell, 2010). Therefore, the results of Subtest 3 and the attitude toward math supplemental tests did not have the statistical power, as the other subtests that met the assumption of homogeneity and were not modified.

Additional Statistics

Effect size*.* In addition to testing, the statistical assumptions as to the effect size using Cohen's *d* was calculated to quantify the size of the difference between the two groups, which is valuable for quantifying the effectiveness of a particular intervention. Effect size is the magnitude of the difference between groups. An independent t-test is calculated using Cohen's *d*.

If the *d* value is .2, there is a small effect size; if the value is .5, the effect size is medium; and, if the value is .8 or greater, there is a large effect size (Howell, 2010).

Confidence interval. The confidence interval (CI) was also calculated to affirm that repeated samples would contain the same population mean, known as the true mean of the population. If the confidence interval is 95%, then the same mean scores would result from this study 95% of the time. The upper and lower bound values calculate the range of mean for the 95% CI.

Welch-Satterthwaite correction. When homogeneity is not met, a modification of the independent t-test is required (Sheskin, 2011). When data is heterogeneous, normal, and unbalanced, the Welch-Satterthwaite correction is the best control of the Type I error (Howell, 2010). Type 1 error is the incorrect rejection of the null hypothesis. Welch-Satterthwaite correction can be used to establish significance (Kuster, 2013). The Welch-Satterthwaite correction was used in Subtest 3 as well as in the attitude toward math supplemental test because homogeneity was not met for these particular subtests.

Independent t-test. The independent t-test is considered robust with equal-sized groups, meaning that the results are minimally affected by violations of assumptions of normality and violation of homogeneity (Myers et al., 2010). The independent t-test provides modifications to adjust for violations of homogeneity. The statistical analysis was conducted to assess whether the assumptions for the independent t-test were met, which includes the presence of one dependent continuous variable, one independent variable that consists of two categorical independent groups, independence of observations, homogeneity or equality of variances, and the normal distribution of the residuals or the normality (Myers et al., 2010). The following detailed analysis represents the statistical results for each hypothesis.

Detailed Analysis

First Hypothesis: H_01

The first hypothesis states,

H_01 There is no effect for game-based learning instruction on fourth-grade Title 1 learners' achievement in recognizing signs and symbols related to mathematics.

An independent t-test was conducted to determine the effects of game-based treatment on Title 1 learners' recognition of signs and symbols. The subjects were divided into two groups: an experiential group ($n = 40$) and a comparative group ($n = 40$). The experiential group was treated with the game-based computer system, Dreambox. Within the data, there was an outlier. The Shapiro-Wilk test was used to test the assumption of normality. However, the assumption of normality was not met due to the outlier. There was homogeneity of variances, as assessed by Levene's test for equality of variances ($p = .895$). Data for students-given game-based treatment showed a larger difference (3.20 ± 2.02) than the comparative group (.60 ± 2.79). The difference of 2.60 was statistically significant (95% CI, 1.52 to 3.68) $t\ (78) = 4.79$, $p < .001$, $d = .18$. Table 2 represents the statistical results from the independent t-test. Based on the independent t-test results, the null hypothesis was rejected in favor of the alternative hypothesis. Game-based learning instruction has a positive impact on fourth-grade Title 1 learners' achievement in recognizing signs and symbols related to mathematics. The following tables represent the pre- and post-means and standard deviations for both the comparative and experiential game groups. Tables 2, 3, and 4 show the descriptive statistics results and, lastly, the independent t-test results.

Table 2

Pre and Post Test Descriptive Statistics

		N	*M*	*SD*
Pre1	Control	40	14.9500	3.12106
	Experimental	40	10.8250	2.91668
	Total	80	12.8875	3.64915
Post1	Control	40	15.6250	3.90718
	Experimental	40	14.1750	2.72583
	Total	80	14.9000	3.42589

Table 3

Mean Gain Scores for Control and Experimental Group

Group	*M*	*SD*	*N*
Control	.600	2.79009	40
Experimental	3.20	2.01533	40
Total	1.90	2.74945	80

Note. Dependent variable: Dif1

Table 4

Independent Samples Test

	T-Test for equality of means				
	t	df	Sig.(2-tailed)	Mean difference	Std. error difference
Equal variances assumed	4.778	78	.000	2.60000	.54420

Second Hypothesis: $H_0$2

The second hypothesis states,

$H_0$2 There is no effect for game-based learning instruction on fourth-grade Title 1 learners' achievement in mathematical computation.

An independent t-test was conducted to determine the effects of game-based treatment on Title 1 learners' mathematical computation. Subjects were divided into two groups: an experiential group (n = 40) and a comparative group (n = 40). The experiential group was treated with the game-based computer system, Dreambox. There were no outliers as assessed by the boxplot. The assumption of normality was met as assessed by the Shapiro-Wilk test of normality ($p < .05$). There was homogeneity of variances, as assessed by Levene's test for equality of variances ($p = .257$). The data for the students given game-based treatment showed a larger difference (3.58 ± 2.30) than the comparative group (1.70 ± 1.87). The difference of 1.88 was statistically significant (95% CI, .94 to 2.81) t (78) = 3.99, $p < .001$, d =.15. Table 7 represents the statistical results from the independent t-test. Based on the independent t-test results, the null hypothesis was rejected in favor of the alternative hypothesis. Game-based learning instruction has a positive impact on the fourth-grade Title 1 learners' achievement in mathematical computation. The following tables represent the pre- and post-means and standard deviations for both the comparative and experiential game groups. Tables 5, 6, and 7 display the descriptive statistics results and, lastly, the independent t-test results.

Table 5

Pretest and Posttest Descriptive Statistics

		N	*M*	*SD*
Pre2	Control	40	14.1500	2.83341
	Experimental	40	10.0000	2.08782
	Total	80	12.0750	3.23656
Post2	Control	40	15.6000	2.79009
	Experimental	40	13.6500	2.51712
	Total	80	14.6250	2.81665

Table 6

Mean Gain Scores for Control and Experimental Group

Group	M	SD	*N*
Control	1.70	1.87014	40
Experimental	3.57	2.30815	40
Total	2.63	2.29056	80

Note. Dependent variable: Dif2

Table 7

Independent Samples Test

	T-Test for equality of means				
	t	*SD*	Sig. (2tailed)	Mean difference	Std. error difference
Equal variances assumed	3.992	78	.000	1.87500	.46971

Third Hypothesis: H_03

The third hypothesis states,

H_03 There is no effect for game-based learning instruction on fourth-grade Title 1 learners' achievement in understanding everyday life mathematics.

An independent-test with a Welch-Satterthwaite correction was conducted to determine the effects of game-based treatment on Title 1 learners in understanding everyday life mathematics. The subjects were divided into two groups: an experiential group (n = 40) and a comparative group (n = 40). The experiential group was treated with the game-based computer system, Dreambox. The assumption of normality was met as assessed by the Shapiro-Wilk test of normality. There was a violation as to the homogeneity of variances, as assessed by Levene's test for equality of variances (p = .004). The data for students given game-based treatment showed a larger difference (3.73 ± 1.83) than the comparative group (.95 ± 3.15). The difference of 2.78 was statistically significant (95% CI, 1.63 to 3.92) t (62.50) = 4.82, p < .001, d =.21. Table 10 represents the statistical results from the independent t-test with the Welch-Satterthwaite correction. Based on the results with the Welch-Satterthwaite correction, the null hypothesis was rejected in favor of the alternative hypothesis. Game-based learning instruction had a positive impact on the fourth-grade Title 1 learners' achievement in understanding everyday life mathematics. Tables 8, 9, and 10 represent the pre- and post-means and standard deviations for both the comparative and experiential game groups. Tables 8, 9, and 10 show the descriptive statistics results and, lastly, the independent t-test with Welch-Satterthwaite corrections and results.

Table 8

Pretest and Posttest Descriptive Statistics

		N	*M*	*SD*
Pre3	Control	40	10.3750	4.67227
	Experimental	40	6.2750	3.52273
	Total	80	8.3250	4.59988
Post3	Control	40	11.1500	4.25200
	Experimental	40	10.0000	3.47887
	Total	80	10.5750	3.90318

Table 9

Mean Gain Scores for the Control and Experimental Groups

Group	*M*	*SD*	*N*
Control	.950	3.15375	40
Experimental	3.72	1.82557	40
Total	2.33	2.91632	80

Note. Dependent variable: Dif3

Table 10

Independent Samples Test

	T-Test for equality of means				
	t	*SD*	Sig. (2tailed)	Mean difference	Std. error difference
Equal variances assumed	4.816	78	.000	2.77500	.57617
Equal variances not assumed	4.816	62.498	.000	2.77500	.57617

Fourth Hypothesis: $H_0 4$

The fourth hypothesis states,

$H_0 4$ There is no effect for game-based learning instruction on fourth-grade Title 1 learners' achievement in solving mathematical word problems.

An independent t-test was conducted to determine the effects game-based treatment on Title 1 learners in solving mathematical word problems. Subjects were divided into two groups: an experiential group (*n* = 40) and a comparative group (*n* = 40). The experiential group was treated with the game-based computer system, Dreambox. The assumption of normality was met as assessed by the Shapiro-Wilk test of normality and homogeneity of variances, as assessed by Levene's test for equality of variances (*p* = .11). The data for students' given game-based treatment showed a larger difference (3.68 ± 1.85) than the comparative group (1.40 ± 6.42). This difference of 2.28 was statistically significant (95 % CI, 1.30 to 3.25) *t* (78) = 4.65, *p* < .001, *d* = .17. Table 13 represents the statistical results from the independent t-test. Based on the independent t-test results the null hypothesis was rejected in favor of the alternative hypothesis. Game-based learning instruction had a positive impact on fourth-grade Title 1 learners' achievement in solving mathematical word problems. Tables 11, 12, and 13 represent the pre- and post-means and standard deviations for both the comparative and experiential game groups. Tables 11, 12, and 13 show the descriptive statistics results and, lastly, the independent t-test *p*-value statistics.

Table 11

Pretest and Posttest Descriptive Statistics

		N	*M*	*SD*
Pre4	Control	40	6.1000	2.47863
	Experimental	40	4.2500	1.95789
	Total	80	5.1750	2.40661
Post4	Control	40	7.5000	2.84650
	Experimental	40	7.9500	2.63069
	Total	80	7.7250	2.73271

Table 12

Mean Gain Scores for the Control and Experimental Groups

Group	*M*	*SD*	*N*
Control	1.40	2.47863	40
Experimental	3.67	1.84513	40
Total	2.53	2.45436	80

Note. Dependent variable: Dif4

Table 13

Independent Samples Test

	T-Test for equality of means				
	t	*df*	Sig. (2tailed)	Mean difference	Std. error difference
Equal variances assumed	4.656	78	.000	2.27500	.48857

Fifth Hypothesis: H_05

The fifth hypothesis states,

H_05 There is no effect for game-based learning instruction on fourth-grade Title 1 learners' attitude toward mathematics.

A Welch-Satterthwaite was conducted to determine the effects of game-based treatment on Title 1 learners' attitude toward mathematics. The subjects were divided into two groups: an experiential group (n = 40) and a comparative group (n = 40). The experiential group was treated with the game-based computer system, Dreambox. The assumption of normality was met as assessed by the Shapiro-Wilk test of normality. There was a violation of homogeneity of variances, as assessed by Levene's test for equality of variances (p = .00). Descriptive data for the mean and standard deviation are presented in Table 14. The data for students' given game-based treatment showed a larger difference (5.43 ± 3.17) than the comparative group (0.30 ± 6.42). The difference of 5.13 was a statistically significant (95% CI, 2.87 to 7.38) t (56.96) = 4.53, p < .001, d =.30. Table 16 represents the statistical results from the independent t-test. Based on the independent t-test results with the Welch-Satterthwaite corrections, the null hypothesis was rejected in favor of the alternative hypothesis. Game-based learning instruction has a positive impact on the fourth-grade Title 1 learners' attitude toward mathematics. Tables 14, 15, and 16 show the descriptive statistics results and, lastly, the independent t-test results with the Welch-Satterthwaite corrections.

Table 14

Pre- and Post-Descriptive Statistics

		N	*M*	*SD*
Pre	Control	40	46.5000	8.55150
	Experimental	40	41.5500	8.78504
	Total	80	44.0250	8.96685
Post	Control	40	47.5250	7.88048
	Experimental	40	46.8500	8.27895
	Total	80	47.1875	8.03803

Table 15

Mean Gain Scores for the Control and Experimental Groups

Group	*M*	*SD*	*N*
Control	.300	6.41792	40
Experimental	5.43	3.16947	40
Total	2.86	5.65180	80

Note. Dependent variable: Attdif

Table 16

Independent Samples Test

	T-Test for equality of means				
	t	*df*	Sig. (2tailed)	Mean difference	Std. error difference
Equal variances assumed	4.528	78	.000	5.12500	1.13176
Equal variances not assumed	4.528	56.955	.000	5.12500	1.13176

Summary of Results

Research Question 1 asked, “What are the effects of a game-based learning supplemental instruction on the math achievement of Title 1 students?” The results of the subtests are included below. The subtests’ results represent the math learning for mathematical symbols and concepts, computation, mathematics in everyday life, word problems, and attitude toward mathematics (supplemental). Overall, the students treated with game-based learning showed enhanced growth in the areas tested.

Subtest 1

Subtest 1 tested students’ knowledge of signs, symbols, words, and phrases that are used in math. In Subtest 1 both the comparative group (n = 40) and the experiential group (n = 40) improved over the seven-week period. However, the experiential group (M =3.20, SD = 2.02) showed a greater improvement than the comparative group (M = .60, SD = 2.79). There was statistical significance present in this subtest between subjects, as the p-value less than 0.01 was less than the alpha value at 0.05. The experiential group demonstrated more progress than the comparative group in recognizing signs, symbols, word, and phrases in math.

Subtest 2

Subtest 2 tested students’ ability to add, subtract, multiply, and divide representing student computational skills. In Subtest 2, both the comparative group (n = 40) and the experiential group (n = 40) improved over the seven-week period. However, the experiential group (M = 3.58, SD = 2.30) that received the game-based treatment showed greater improvement than the comparative group (M = 1.70, SD = 1.87). There was statistical significance present in this subtest between subjects, as the p-value less than 0.01 was less than the alpha value at 0.05. The experiential group demonstrated more progress than the comparative group in computational skills.

Subtest 3

Subtest 3 tested students' ability to apply mathematics in everyday life. In Subtest 3, both the comparative group (*n* = 40) and the experiential group (*n* = 40) improved over the seven-week period. However, the experiential group (*M* = 3.73, *SD* = 1.83) showed greater gain scores than the comparative group (*M* = .95, *SD* = 3.15). The subtest between subjects was significant, as the *p*-value less than 0.01 was less than the alpha value at 0.05. Students who received the game-based treatment demonstrated more progress than the comparative group in applying math to everyday life.

Subtest 4

Subtest 4 tested students' ability to solve a series of word problems. In Subtest 4, both the comparative group (*n* = 40) and the experiential group (*n* = 40) improved over the seven-week period. However, the experiential group (*M* = 3.68, *SD* = 1.85) who received the game-based treatment showed greater gain scores than the comparative group (*M* = 1.40, *SD* = 6.42). The between-subjects' result was significant, as the *p*-value less than 0.01 was less than the alpha value at 0.05. Students receiving the game-based treatment demonstrated more progress than the comparative group in solving word problems.

Supplemental Attitude Subtest

The supplemental attitude toward math subtest examined students' attitude toward math. In this subtest, both the comparative group (*n* = 40) and the experiential group (*n* = 40) improved over the seven-week period. However, the experiential group (*M* = 5.43, *SD* = 3.17) that received the game-based treatment showed greater gain scores than the comparative group (*M* = .30, *SD* = 6.42). The subtest for between-subjects was significant, as the *p*-value less than 0.01 was less than the alpha value at 0.05. Students who received the game-based treatment demonstrated a more positive attitude toward math than the comparative group.

Overall, members of the experiential group showed greater gain scores in subtests scores than members of the comparative group. There was an overall positive effect regarding game-based learning. Computer-generated math games aligned with the curriculum may have contributed to greater learning gains in comparison to traditional pedagogical approaches to teaching mathematical competencies to fourth-grade learners attending Title 1 schools.

Summary

The data results for the research questions and analysis of the findings are presented in this chapter. The population of the Title I school in this study was Hispanic and African American from socioeconomically disadvantaged backgrounds. The research question focused on determining the effect of game-based learning on the mathematical competencies of fourth-grade math students attending the Title 1 school. The TOMA-3 was administered to the experiential and comparative group. Results were analyzed using both inferential and descriptive statistics.

Five subtest were administered. Each subtest finding indicated that (a) game-based learning instruction had a positive impact on fourth-grade Title 1 learners' achievement in recognizing signs and symbols related to mathematics; (b) game-based learning instruction has a positive impact on fourth-grade Title 1 learners' achievement in computation in mathematics, (c) game-based learning instruction has a positive impact on fourth-grade Title 1 learners' achievement in understanding everyday life mathematics; (d) game-based learning instruction has a positive impact on fourth-grade Title 1 learners' achievement in solving mathematical word problems; and (e) game-based learning instruction has a positive impact on fourth-grade Title 1 learners' attitude toward mathematics. Positive impact was noted for each subtest.

The experiential group showed greater gain scores in math tested skills than the participants in the comparative group. After a variety of subtests administered for the TOMA-3, the results yielded clearly show more improvement within the experiential group in terms of mathematical competency. After testing the hypotheses, all the null hypotheses were rejected. The next chapter discusses the analysis of the results, conclusions, and recommendations on how best learning institutions can utilize game-based activities to improve learning among the fourth-grade students.

Chapter 5: Conclusions

The purpose of this chapter is to discuss the outcomes of the quasi-experimental game-based learning study. An analysis of the findings is included for each hypothesis. Additionally, deductions from the study and the relationship to the literature are discussed. Furthermore, limitations and implications for future practice are explored. Recommendations are given for future research. The findings presented in this chapter provide a summary of the results of the study on game-based learning and its effect on fourth-grade students attending a low-income Title 1 school.

Summary of Results

This study explored game-based learning as a supplement to the fourth-grade math curriculum. The research focused specifically on game-based learning and math achievement among fourth-grade students attending a Title 1 school. In the elementary school, 98% of the students were on free and reduced lunch.

A comparative group of 40 fourth-grade students and an experiential group of 40 fourth-grade students were given TOMA-3 pre- and post-assessments. TOMA-3 consists of five individual tests, which are referred to as subtests. The fifth TOMA-3 test assesses the students' attitude toward mathematics. Both the experiential and comparative groups were administered a pre- and posttest for each subtest. The experiential group was treated with the game-based computer math system. The data were collected and then analyzed to determine the effects of game-based learning on fourth-grade Title 1 elementary students' math achievement. Listed below is an analysis of the research findings for the research question.

RQ. What are the effects of a game-based learning supplemental instruction on math achievement of Title 1 students?

This study of 80 fourth-grade students consisting of both comparative (*n* = 40) and experiential (*n* = 40) group yielded results that indicated that game-based learning improved student skills in (a) recognizing signs and symbols, (b) math computation, (c) understanding math in everyday life, (d) math word problem solving, and (e) students' attitudes toward math. There were five math skills tested. The null hypothesis for all five hypotheses were rejected.

First Hypothesis: $H_0 1$

The first hypothesis states,

$H_0 1$ There is no effect for game-based learning instruction on fourth-grade Title 1 learners' achievement in recognizing signs and symbols related to mathematics.

This hypothesis was rejected. In the mathematical symbols and concepts category, students were required to identify math symbols from a given four choices. This assessment demonstrated students' ability to recognize signs such as %, 90-degree angles, Roman numerals, as well as formulas for perimeter, area, and others. Students in the experiential group were more proficient in recognizing these symbols, suggesting positive growth for students in the ability to recognize math signs and symbols as a result of the game-based learning. However, there was an outlier in this subtest that is known to affect the significance of the study. Even with the outlier positive achievement was noted for the experiential group.

Second Hypothesis: $H_0 2$

The second hypothesis states,

$H_0 2$ There is no effect for game-based learning instruction on fourth-grade Title 1 learners' achievement in mathematical computation.

This hypothesis was rejected. To test this hypothesis, the researcher used the TOMA-3 pre- and post-assessments. In the computation component, the students were required to apply their math skills to solve numerical problems. Computation, without words or phrases, constituted the entire subtest. Students completed as many computational problems as possible within the allotted 20-minute time frame. There was an statistical difference between students' achievement in mathematical computation.

Third Hypothesis: $H_0$3

The third hypothesis states,

$H_0$3 There is no effect for game-based learning instruction on fourth-grade Title 1 learners' achievement in understanding everyday life mathematics.

This hypothesis was rejected. The subtest labeled Mathematics in Everyday Life measured the students' knowledge of mathematics in everyday life situations. Similar to Subtest 1, students had four possible answers: A, B, C, and D. There was a statistical difference between students' achievement in understanding everyday life mathematics. Students in the experiential group (receiving game-based treatment) outperformed students in the comparative group (not receiving game-based treatment).

Students' responses to math in every day life were affected by their background knowledge and life experiences. For example, one question asked about the third quarter of a football game. Some students may watch football while others may not. Therefore, they might have had difficulty in understanding what was being asked. Other questions asked about area codes, insurance, and tax. These topics were based on home and life experiences that the students may or may not have been exposed to in real life. However, based on the results, students who experienced game-based treatment outperformed students in understanding math in everyday life. This suggests that computer games have the potential to influence students' knowledge of everyday life concepts beyond traditional approaches to the curriculum.

Fourth Hypothesis: $H_0$4

The fourth hypothesis states,

$H_0$4 There is no effect for game-based learning instruction on fourth-grade Title 1 learners' achievement in solving mathematical word problems.

This hypothesis was rejected. Learners were to answer a series of progressively difficult word problems. The initial questions required a one-step task and then progressed to multi-step tasks. No answer choices were given; hence, students had to solve the problems on their own. There was a statistical difference between students' achievement in solving mathematical word problems. Students in the experiential group (receiving game-based treatment) outperformed students in the comparative group (not receiving game-based treatment).

Fifth Hypothesis: $H_0$5

The fifth hypothesis states,

$H_0$5 There is no effect for game-based learning instruction on the fourth-grade Title 1 learners' attitude toward mathematics.

This hypothesis was rejected. The supplemental component required the learners to indicate their attitudes toward math instructions and their ability to understand and utilize math. Students were given four options: *yes definitely; closer to yes; closer to no;* and *no, definitely*. There was a statistical difference between the students' attitude toward mathematics. Students in the experiential group (receiving game-based treatment) expressed a more positive attitude toward math than the comparative group (not receiving game-based treatment).

Subtests

The learners' attitude toward mathematics subtests yielded conclusive results. Students who experienced the game-based system were more positive about math than students exposed solely to traditional pedagogy. Implications from this subtest suggested that computer games can positively influence students' attitude toward math and motivation to engage in math activities. The following subtests helped to answer the guiding research question.

RQ. What are the effects of a game-based learning supplemental instruction on the math achievement of fourth-grade Title 1 students?

Subtest 1

All students were exposed to mathematical signs and symbols related to fourth-grade math. The curriculum specifically addressed geometrical symbols such as angles, number lines, and formulas. Through game-based treatment, students had additional exposure to signs and symbols that may have led to greater proficiency in recognition. Additionally, students experiencing game-based treatment had a more positive attitude and may have had a greater interest in sign and symbols leading to greater learning.

Subtest 2

All students were exposed to math computation, including adding, subtracting, multiplying, and dividing. Students in both the experiential and the comparative groups showed considerable improvements with this component compared to other academic components. Through game-based treatment, students had additional exposure to math computation that may have led to greater proficiency in math computation. Additionally, students experiencing game-based treatment had a more positive attitude (experiential group: 5.43 ± 3.17; comparative group: 0.30 ± 6.42) and may have had a greater interest in math computation leading to greater learning.

Subtest 3

Students' everyday life experiences were questioned in this subtest. Students' experiences varied. Some students were familiar with concepts that differed from taxes to gasoline pumps. Some students were limited in knowledge and everyday life experiences. However, students who experienced game-based treatment outperformed the students who did not. The more positive attitude evidenced in the supplemental attitude assessment (experiential group: 5.43 ±3.17; comparative group, 0.30 ± 6.42) could have caused greater awareness or even engagement in everyday math activities.

Subtest 4

All students were exposed to solving math problems. Students learned to apply math computation to stories presented to illicit understanding of the usage of computation. The computer system gave the experiential group oral and visual game stories. This supplemental enrichment evidenced greater improvements with the game-based group than the comparative group. Additionally, students experiencing game-based treatment had a more positive attitude and may have had a greater interest in math problem solving leading to greater learning.

Supplemental Attitude Test

Students who experienced game-based learning showed a huge improvement (5%) in their attitude toward math. The comparative group showed minimal improvement (.3%). Game-based environments resulted in positive student morale.

Overall game-based treatment improved students’ achievement in recognizing signs and symbols, mathematical computation, understanding math in everyday life, and attitude toward mathematics. Each of the subtests showed statistical significance. In Subtest 1, there was a statistical outlier that could have challenged the significance of the study, but through robust statistics, the study’s result was significant. In Subtest 3, for understanding math in everyday life and in the attitude toward mathematics, a modified statistical test known to be robust against samples that are not homogeneous was run and both study results were significant. These results are important for instruction. Along with positive attitudes toward math, students also demonstrated academic progress above their peers who were not exposed to game-based treatment. Computer-generated games influenced students' outlook and outcomes in math.

Discussion of Results

Both the comparative group and the experiential group achieved at higher levels in the five tested categories: recognizing signs and symbols, mathematical computation, understanding math in everyday life, and attitude toward mathematics after the seven-week period. The experiential group who experienced game-based treatment achieved more growth than the comparative group. This study attributed the progress of the experiential group to the computer-generated game system. The game system was aligned to curricula standards and therefore was able to provide a relevant enhancement to the set curriculum. All of the students experienced traditional pedagogical approaches. The computer game-based system was only used to supplement traditional instruction.

The computer-generated environment had its greatest impact on the experiential group's attitude toward math. The results demonstrated that a game-based environment had its greatest effect on fourth-grade Title 1 students' attitudes toward math. It is interesting that the students in the comparative group had lower scores for math attitude. It appears that game-based learning is effective in promoting student interest in math.

All of the students benefitted from supplemental math instruction, whether traditional or traditional with game-based treatment. It is evident from the results that the addition of game-based treatment made a positive impact on the fourth-grade students attending a Title 1 school. Traditional instruction did impact achievement in computation and solving word problems. Little progress was made in other academic areas or in students' attitudes toward math.

The game-based system was able to impact academically as well with students' attitudes toward math. This study provided evidence for the addition of game-based environments into traditional pedagogy. Students who experienced game-based treatment demonstrated marked improvements in each of the four academic components. Game-based treatment had an evident and positive impact on this population's academic achievement. Literature has shown that game-based environments can both increase academic achievement or not affect academic achievement (Jabbar & Felicia, 2015; Ke et al., 2015; Kim et al., 2016). Unlike the literature, no controversial academic outcomes were established. Each academic component (recognizing mathematical signs and symbols; math computation; understanding math in everyday life; and math word problem solving) yielded positive academic results. According to this study, computer-generated math games aligned with the curriculum contributes to greater learning gains in elementary-aged math students attending Title 1 schools.

Discussions of Results in Relation to Literature

Game-based literature suggested that computer-generated game positively affect student achievement (Hsieh et al., 2016; Shin et al., 2012). Research predominantly found that game environments improved student motivation, confidence, and engagement (Hsieh et al., 2016; Naik, 2015). Even though academic achievement was noted, there were also some controversial results (Fengfeng, 2008). Some researchers found correlations between computer-generated games and academic achievements (Byun & Loh, 2015) and others did not (Zhang, 2015). The literature suggested that computer-games were best when aligned with pedagogy. The majority of research has not addressed game-based learning for elementary-aged students attending Title 1 schools.

This study explored math computer-based games exclusively with fourth-grade students attending a Title 1 school. The study employed four academic mathematical components, including (a) recognizing mathematical signs and symbols, (b) math computation, (c) understanding math in everyday life, and (d) solving math word problem. There was a supplemental test of students' attitude toward math. As the literature suggested, the computer games were aligned with pedagogy and included math instruction. The game-based computer system utilized was Dreambox, a mathematical program that was aligned with math curriculum standards.

Limitations

The participants in this study were fourth-grade students who came from a Title 1 school in the southern region of the United States. As such it is difficult to generalize the results across other populations outside of this specific subgroup. The curricula standards were those from the particular southern state and results may not be the same across curricula standards of every state. Additionally, only the computer-generated system, Dreambox, was utilized in this study. Other computer-generated systems may not yield the same results. Difficulties arose in obtaining the necessary technologies that the study warranted. Budget conflicts prevented the researcher from obtaining the computers expected for the study.

Another limitation was the lack of access to technology. The computers for the program were borrowed, and I needed to work around the schedules of other fourth-grade teachers. Several scheduling conflicts and budget reforms caused me, as the researcher and instructor for the program implementation, to adjust for difficulties obtaining the required technology. These difficulties included transporting computers from various classrooms. Some of the fourth-grade teachers were justifiably reluctant to lend out their computers for the study. One or two computers were borrowed from teachers in the fourth-grade classes and marked to ensure that the computers were returned to the rightful owner.

Furthermore, not all of the teachers were convinced of the merits of game-based learning and indicated initial reluctance to release students for participation in the study. One-to-one conferences were held to discuss the game-based learning application and to show how the program was curriculum based. In addition, the envisioned launch of the quasi-experiment was delayed by inclement weather conditions that disrupted the statewide school openings. Therefore, a projected eight-week study was condensed to seven weeks. Additionally, the participants experienced a traumatic national disaster during the time of the study that may have impacted performance results.

Complications arose in analyzing the results of the quasi-experiment. As discussed earlier, I discovered a lower-than-normal score on a posttest. This outlier affected the statistical normality of the study. Results were not as robust as other subtests.

Implications of the Results for Practice, Policy, and Theory

Game-based learning increased student growth in mathematics. Even though students in both the experiential and comparative groups improved through general classroom instruction, computer-generated math games contributed to greater learning outcomes in comparison to traditional approaches to teaching mathematics. The practical application suggested that computer games would benefit students as an instructional supplement. Whether game-based learning strategies would be used to review information that had already been learned, or if it would teach new content, gameplay offers an engaging and fun strategy for teachers to add into their instructional practices.

Conversely, there are barriers to the implementation of a game-based environment. Even if elementary school instructors want to implement game scenarios into the curriculum, there are obstacles that must be overcome, particularly in schools that lack the requisite resources to facilitate this process. Expense and budget proved to be limitations even in this study.

To remedy limitations, feedback from teachers, stakeholders, and students is necessary for school districts serving high poverty populations to figure out the most optimal way of incorporating games into the learning process. One suggestion is that schools should focus on game-based learning systems that address the particular grade level standards. The games should align with the specific content being taught.

Recommendations for Further Research

Additional research is needed on game-based learning schools in other regions of the country and from different populations. The current study measured progress over a seven-week period. Further research should analyze students' progress over a longer time providing an in-depth look into the effects of game-based treatments on the entire year's curriculum.

Comparing students with high baseline scores to students with low baseline scores could further inform game-based research. Comparing boys to girls, different age groups, or bilingual and ESL populations may also add to the literature. Multiple comparisons of various populations should address the influences of game-based environments so as to address the entire educational community.

Further investigation into computer-based game systems should be conducted to ensure curriculum standards are supported. Dreambox was specifically aligned with the fourth grade standards for schools in this particular region. Future researchers should confirm that programs are actual supplements to the utilized curriculum.

Conclusions

After reviewing the relevant literature regarding the effects of game-based learning on student achievement and conducting a study intended to examine the effects on fourth-grade students attending a Title 1 school, I concluded that game-based learning had a positive effect on student learning and motivation. The difference in improvement between the comparative group and experiential group demonstrated that game-based learning had the potential to benefit students academically. In addition, game-based treatment helped students in the experiential group to develop a positive attitude toward math. Utilizing game instruction as a supplement proves advantageous and helps to promote learning and positive attitudes for students of math.

References

Abraham, R. A., Slate, J. R., Saxon, D. P., & Barnes, W. (2014). College-readiness in math: A conceptual analysis of the literature. *Research & Teaching in Developmental Education, 30*(2), 4–34.

Abramovich, S. (2010). *Topics in mathematics for elementary teachers: A technology-enhanced experiential approach*. Charlotte, NC: Information Age Publishing.

Adachi, P. J., C., & Willoughby, T. (2013). More than just fun and games: The longitudinal relationships between strategic video games, self-reported problem solving skills, and academic grades. *Journal of Youth and Adolescence, 42*(7), 1041–1052.

Adamson, F., & Darling-Hammond, L. (2012) Funding disparities and the inequitable distribution of teachers: Evaluating sources and solutions. *Education Policy Analysis Archives, 20*(37). Retrieved from http://epaa.asu.edu/ojs/article/view/1053

Admiraal, W., Huizenga, J., Akkerman, S., & Dam, G. T. (2011). The concept of flow in collaborative game-based learning. *Computers in Human Behavior, 27*(3), 1185-1194. http://dx.doi.org/10.1016/j.chb.2010.12.013

Babbie, E. R. (2008). *The basics of social research*. Belmont, CA: Thomson/Wadsworth.

Baek, Y. (2010). *Gaming for classroom-based learning: Digital role playing as a motivator of study*. Hershey, PA: Information Science Reference.

Baek, Y. (2014). Searching for roles of intrinsic motivation in instructional games. *Journal of Educational Research Institute, 16*(1), 83–193. http://dx.doi.org/10.15564/jeri.2014.05.16.1.103

Bagheri, M. M. (2015). Intelligent and adaptive tutoring systems: How to integrate learners. *International Journal of Education, 7*(2), 1. http://dx.doi.org/10.5296/ije.v7i2.7079

Barde, M. P, & Barde, P. J. (2012). What to use to express the variability of data: Standard deviation or standard error of mean? *Perspectives in Clinical Research*, *3*(3), 113-116.

Becker, T. E., Atinc, G., Breaugh, J. A., Carlson, K. D., Edwards, J. R., & Spector, P. E. (2015). Statistical control in correlational studies: 10 essential recommendations for organizational researchers. *Journal of Organizational Behavior, 37*(2), 157–167. http://dx.doi.org/10.1002/job.2053

Berg, G., (2016). *Low-Income students and the perpetuation of inequality*. London: Routledge.

Berger, N., & Archer, J. (2015). School socio-economic status and student socio-academic achievement goals in upper secondary contexts. *Social Psychology of Education*, *19*(1), 175–194. http://dx.doi.org/10.1007/s11218-015-9324-8

Berger, N., & Archer, J. (2016). School socio-economic status and student socio-academic achievement goals in upper secondary context. *Journal Social Psychology of Education, 19*, 175–194.

Bernerth, J. B., & Aguinis, H. (2015). A critical review and best-practice recommendations for control variable usage. *Personnel Psychology*, *69*(1), 229–283. http://dx.doi.org/10.1111/peps.12103

Bourgonjon, J., Valcke, M., Soetaert, R., & Schellens, T. (2010). Students’ perceptions about the use of video games in the classroom. *Computers & Education*, *54*(4), 1145–1156. http://dx.doi.org/10.1016/j.compedu.2009.10.022

Bowen, D. J., Kreuter, M., Spring, B., Cofta-Woerpel, L., Linnan, L., Weiner, D., . . . Fernandez, M. (2009). How we design feasibility studies. *American Journal of Preventive Medicine*, *36*(5), 452–457.

Brookhart, S. (2014). *Setting the stage for 21st century learning.* Literacyworldwide.org. Retrieved from https://www.literacyworldwide.org/docs/default-source/bonus-materials/introduction-358.pdf?sfvrsn=4

Brown, V., Cronin, M., & Bryant, D. (2012). *Test of mathematical abilities* (3rd ed., White Paper). Retrieved from http://www.proedinc.com/downloads/14210toma-3whitepaper.pdf

Buchinger, D., & Hounsell, M. D. (2018). Guidelines for designing and using collaborative-competitive serious games. *Computers & Education, 118*(6), 133–149. http://dx.doi.org/10.1016/j.compedu.2017.11.007

Burguillo, J. C. (2010). Using game theory and competition-based learning to stimulate student motivation and performance. *Computers & Education, 55*(2), 566–575. http://dx.doi.org/10.1016/j.compedu.2010.02.018

Byun, J., & Loh, C. (2015). Audial engagement: Effects of game sound on learner engagement in digital game-based learning environments. *Computers in Human Behavior*, *46*, 129–138.

Callaghan, M. J., McCusker, K., Losada, J. L., Harkin, J., & Wilson, S. (2013). Using game-based learning in virtual worlds to teach electronic and electrical engineering. *IEEE Transactions on Industrial Informatics*, *9*(1), 575–584.

Campbell, D. T., & Stanley, J. C. (2015). *Experimental and quasi-experimental designs for research*. Cambridge, England: Ravenio Books.

Carenys, J., & Moya, S. (2016). Digital game-based learning in accounting and business education. *Accounting Education, 25*(6), 598–651. http://dx.doi.org/10.1080/09639284.2016.1241951

Carr, J. M. (2012). Does math achievement happen when iPads and game-based learning are incorporated into fifth-grade mathematics instruction? *Journal of Information Technology Education: Research, 11*(1), 269–286.

Carter, R. E. (2013). A standard error: Distinguishing standard deviation from standard error. *Diabetes, 62*(8), e15-e15.

Challco, G. C., Andrade, F. R. H., Borges, S. S., Bittencourt, I. I., & Isotani, S. (2016). Toward a unified modeling of learner's growth process and flow theory. *Journal of Educational Technology & Society, 19*(2), 215–227.

Chao, T., Chen, J., Star, J. R., & Dede, C. (2016). Using digital resources for motivation and engagement in learning mathematics: Reflections from teachers and students. *Springer International Publishing*, *3*(2), 253-277. http://dx.doi.org/10.1007/s40751-016-0024-6

Cheon, S. H., & Reeve, J. (2015). A classroom-based intervention to help teachers decrease students' amotivation. *Contemporary Educational Psychology, 40*, 99–111. http://dx.doi.org/10.1016/j.cedpsych.2014.06.004

Chia, N. K. H., Ng, A. G. T., Tan, S. S. K., & Wee, L. H. (2014). A comparison of cognitive equations of mathematics learning process between the American and Singaporean students with dyscalculia. *Educational Research International*, *1*(3), 1–14.

Chisholm, J. D., & Kingstone, A. (2015). Action video games and improved attentional control: Disentangling selection- and response-based processes. *Psychonomic Bulletin & Review, 22*(5), 1430-1436. http://dx.doi.org/10.3758/s13423-015-0818-3

Cicchino, M. I. (2015). Using game-based learning to foster critical thinking in student discourse. *Interdisciplinary Journal of Problem-Based Learning, 9*(2), 1–15. http://dx.doi.org/10.7771/1541-5015.1481

Clark, T. C. (2014). *Differences in math achievement: Utilizing supplemental computer based instruction and traditional instruction.* (ERIC Document Reproduction No. ED567298)

Claydon, L. S. (2015). Rigor in quantitative research. *Nursing Standard*, *29*(47), 43. Retrieved from http://dx.doi.org.cupdx.idm.oclc.org/10.7748/ns.29.47.43.e8820

Colclough, C. (2012). *Education outcomes and poverty in the global South: A reassessment*. London: Routledge.

Collins, H. (2010). *Creative research: The theory and practice of research for the creative industries.* Lausanne, Switzerland: AVA Academia.

Cook, T. D. (2015). *Quasi-experimental design*. Wiley Encyclopedia of Management. San Francisco, CA: John Wiley and Sons.

Courtney, M. G., & Chang, K. C. (2018). Dealing with non-normality: An introduction and step-by-step guide using R. *Teaching Statistics, 40*(2), 51–59. http://dx.doi.org/10.1111/test.12154

Creamer, E. G. (2018). Enlarging the conceptualization of mixed method approaches to grounded theory with intervention research. *American Behavioral Scientist*, *62*(7), 919-934. http://dx.doi.org/10.1177/0002764218772642

Creswell, J. W. (2009). *Research, qualitative*, *quantitative, and mixed methods approaches*. Thousand Oaks, CA: Sage.

Creswell, J. W., & Plano Clark, V. L. (2018). *Designing and conducting mixed methods research*. Thousand Oaks, CA: Sage.

Dania, A., & Zounhia, K. (2016). Effects of teaching games for understanding on quantitative and qualitative indexes of grade 3 students' game performance. *Research Quarterly for Exercise and Sport, 87*, S76–S77. (ERIC Document Reproduction No. EJ1108109)

Degol, J. L., & Bachman, H. J. (2015). Preschool teachers' classroom behavioral socialization practices and low-income children's self-regulation skills. *Early Childhood Research Quarterly, 31*(2), 89–100. http://dx.doi.org/10.1016/j.ecresq.2015.01.002

De-Marcos, L., Domínguez, A., Saenz-De-Navarrete, J., & Pagés, C. (2014). An empirical study comparing gamification and social networking on e-learning. *Computers & Education, 75*, 82-91. http://dx.doi.org/10.1016/j.compedu.2014.01.012

Devonshire, I. M., Davis, J., Fairweather, S., Highfield, L., Thaker, C., Walsh, A., . . . Hathway, G. J. (2014). Risk-Based Learning Games Improve Long-Term Retention of Information among School Pupils. *PLoS ONE, 9*(7). http://dx.doi.org/10.1371/journal.pone.0103640

Dickinson, A., & Jill, E. (2014). Exploring the limitations of measures of students' socioeconomic status (SES). *Practical Assessment, Research and Evaluation*, *19*(1), 1–14.

Dieser, O., & Bogner, F. X. (2015). Young people's cognitive achievement as fostered by hands-on-centered environmental education. *Environmental Education Research, 22*(7), 943–957. http://dx.doi.org/10.1080/13504622.2015.1054265

Divjak, B., & Tomic, D. (2011). The impact of game-based learning on the achievement of learning goals and motivation for learning mathematics—Literature review. *Journal of Information and Organization Sciences, 35*(1), 15–30.

Dreambox Learning. (2016). *Our mission is to radically transform the way the world learns.* Retrieved from http://www.dreambox.com/company

Ellis, T. J., &, Levy, Y. (2009). Towards a guide for novice researchers on research methodology: Review and proposed methods. *Issues in Informing Science and Information Technology*, *6*, 323–337.

Erhel, S., & Jamet, E. (2015). The effects of goal-oriented instructions in digital game-based learning. *Interactive Learning Environments, 24*(8), 1744–1757. http://dx.doi.org/10.1080/10494820.2015.1041409

Ertmer, P. A., & Newby, T. J. (2013). Behaviorism, cognitivism, constructivism: Comparing critical features from an instructional design perspective. *Performance Improvement Quarterly*, *26*(2), 43–71. http://dx.doi.org/10.1002/piq.21143

Eseryel, D., Law, V., Ifenthaler, D., Ge1, X., & Miller, R. (2014). An investigation of the interrelationships between motivation, engagement, and complex problem solving in game-based learning. *Journal of Educational Technology & Society*, *17*(1), 42–53.

Feinberg, F. M., Salisbury, L. C., & Ying, Y. (2016). When random assignment is not enough: Accounting for item selectivity in experimental research. *Marketing Science, 35*(6), 976-994. http://dx.doi.org/10.1287/mksc.2016.0991

Felicia, P. (2014). *Game-based learning: Challenges and opportunities*. UK: Cambridge Scholars.

Fengfeng, K. (2008). A case study of computer gaming for math: Engaged learning from game play? *Computers and Education, 51*(4), 1609–1620.

Festus, A. B., & Adeyeye, A. C. (2012). The development and use of mathematical games in schools. Abuja, Nigeria: National Mathematical Centre, Sheda-Kwali.

Filsecker, M., & Hickey, D. T. (2014). A multilevel analysis of the effects of external rewards on elementary students' motivation, engagement and learning in an educational game. *Computers & Education, 75*, 136–148. http://dx.doi.org/10.1016/j.compedu.2014.02.008

Frost, J., & Eden, A. (2014). The effect of social sharing games and game performance on motivation to play brain games. *Games for Health*, 48–55. http://dx.doi.org/10.1007/978-3-658-07141-7_7

Fry, H., Ketteridge, S., & Marshall, S. (2010). *A handbook for teaching and learning in higher education enhancing academic and practice*. Abingdon, UK: Routledge.

Fullerton, J., & Hughes, R. (2016). *DreamBox learning achievement growth.* Center for Educational Policy. Retrieved from http://cepr.harvard.edu/dreambox-learning-achievement-growth

Gerber, H. R., Abrams, S. S., Onwuegbuzie, A. J., & Benge, C. L. (2014). From Mario to FIFA: What qualitative case study research suggests about games-based learning in a US classroom. *Educational Media International*, *51*(1), 16–34. http://dx.doi.org/10.1080/09523987.2014.889402

Grams, D. (2018). *A quantitative study of the use of DreamBox learning and its effectiveness in improving math achievement of elementary students with math difficulties.* (ERIC Document Research No. ED583896)

Habgood, M. J., & Ainsworth, S. E. (2011). Motivating children to learn effectively: Exploring the value of intrinsic integration in educational games. *The Journal of the Learning Sciences*, *20*(2), 169–206.

Hair, J. F., Celsi, M. W., Money, A. H., Samouel, P., & Page, M. J. (2011). *Essentials of business research methods*. Armonk, NY: ME Sharpe.

Halcomb, E., & Hickman, L. (2015). Mixed methods research. *Nursing Standard (2014+), 29*(32), 41. Retrieved from http://dx.doi.org.cupdx.idm.oclc.org/10.7748/ns.29.32.41.e8858

Hamari, J., Shernoff, D. J., Rowe, E., Coller, B., Asbell-Clarke, J., & Edwards, T. (2016). Challenging games help students learn: An empirical study on engagement, flow and immersion in game-based learning. *Computers in Human Behavior*, *54*, 170–179. http://dx.doi.org/10.1016/j.chb.2015.07.045

Hanushek, A. E., Peterson, P., & Woessmann. (2010). *U. S. math performance in global perspective. How well does each state do at producing high-achieving students?* Cambridge, MA: Harvard Kennedy School.

Hanushek, E. A., Woessmann, L., & Peterson, P. E. (2012). Is the U.S. catching up? *Education Next*, *12*(3), 32–41.

Heffner, C. L. (2014). *Quasi-experimental design.* AllPsych. Retrieved from http://allpsych.com/researchmethods/quasiexperimentaldesign.

Heitin, L. (2016). Math teaching: What we’ve learned from research over a decade. *Education Week.* Retrieved from http://edweek.org/edweek/curriculum/2016/07/research_on_math_teaching_what_wve_learned.html

Hodgen, J., & Marks, R. (2013). *The employment equation: Why our young people need more math for today's jobs.* London: *The* Sutton Trust.

Hoe, J., & Hoare, Z. (2013). Understanding quantitative research: Part 1. *Nursing Standard, 27*, 15–17, 52–57, Quiz 58.

Howell, D. C. (2010). *Statistical methods for psychology* (7th ed.). Belmont, CA: Wadsworth.

Hsieh, Y. H., Lin, Y. C., & Hou, H. T. (2016). Exploring the role of flow experience, learning performance and potential behavior clusters in elementary students' game-based learning. *Interactive Learning Environments, 24*(1), 178–193. http://dx.doi.org/10.1080/10494820.2013.834827

Hsin, C. T., Li, M. C., & Tsai, C. C. (2014). The influence of young children's use of technology on their learning: A review. *Educational Technology* & *Society*, *17*(4), 85–99.

Hudson, T. (2012). *The power of technology to reach all students*. Dreambox Learning. Retrieved from http://www.dreambox.com/blog/the-power-of-technology-to-reach-all-students

Hudson, T. (2015). *Nurturing the middle school mathematical mind: Strategies for teaching middle school math.* Retrieved from http://www.miteacher.org/uploads/1/0/3/4/10347810/wp0024_white_paper_tim_h...aical_mind_01_21_2.pdf.

Hung, C., Huang, I., & Hwang, G. (2014). Effects of digital game-based learning on students' self-efficacy, motivation, anxiety, and achievements in learning mathematics. *Journal of Computers in Education, 1*(2–3), 151–166.

Hwang, G. J., Chiu, L. Y., & Chen, C. H. (2015). A contextual game-based learning approach to improving students' inquiry-based learning performance in social studies courses. *Computers & Education, 60*(4), 623–638.

Ifenthaler, D., Eseryel, D., & Ge, X. (2012). Assessment in game-based learning: Foundations, innovations, and perspectives. *Language Learning & Technology, 18*(3), 47–51. Retrieved from http://llt.msu.edu/issues/october2014/review3.pdf

Isaacs, S. (2015). *The difference between gamification and game-based learning.* Retrieved from http://inservice.ascd.org/the-difference-between-gamification-and-game-based-learning/

Iten, N., & Petko, D. (2016). Learning with serious games: Is fun playing the game a predictor of learning success? *British Journal of Educational Technology*, *47*(1), 151–163. http://dx.doi.org/10.1111/bjet.12226

Jabbar, A. I., & Felicia, P. (2015). Gameplay engagement and learning in game-based learning: A systematic review. *Review of Educational Research*, *85*(4), 740–779.

Jacobs, J. (2015). Disrupting the education monopoly. *Education Next*, *15*(1). Retrieved from https://www.educationnext.org/disrupting-the-education-monopoly-reed-hastings-interview/

Jansen, B. R., Schmitz, E. A., & van der Maas, H. L. (2016). Affective and motivational factors mediate the relation between math skills and use of math in everyday life. *Frontiers in Psychology*, *7*, 513. http://dx.doi.org/10.3389/fpsyg.2016.00513

Jayantilal, K., & O'Leary, N. (2016). (Reinforcing) factors influencing a physical education teacher's use of the direct instruction model teaching games. *European Physical Education Review*, *23*(4), 392–411. http://dx.doi.org/10.1177/1356336x16652081

Jeng-Chung, W. (2014). Digital game-based learning supports student motivation, cognitive success, and performance outcomes. *Journal of Educational Technology & Society*, *17*(3), 291–307.

Jitendra, A. K., Griffin, C. C., & Xin, Y. P. (2010). An evaluation of the intended and implemented curricula's adherence to the NCTM standards on the mathematics achievement of third grade students: A case study. *Journal of Curriculum and Instruction*, *4*(2), 33–50.

Johnson, B., & Christensen, L. B. (2012). *Educational research: Quantitative, qualitative, and mixed approaches*. Thousand Oaks, CA: Sage.

Johnston, M. (2017). Secondary data analysis: A method of which the time has come. *Qualitative and quantitative methods in libraries, 3*(3), 619-626. Retrieved from http://www.qqml-journal.net/index.php/qqml/article/view/169

Jong, J., Hong, J., & Yen, C. (2013). Persistence temperament associated with children playing math games between touch panel and embodied interaction. *Journal of Computer Assisted Learning, 29*(6), 569-578. http://dx.doi.org/10.1111/jcal.12017

Jong, M. S. Y. (2015). Does online game-based learning work in formal education at school? A case study of VISOLE. *The Curriculum Journal*, *26*(2), 249–267. http://dx.doi.org//10.1080/09585176.2015.1018915

Kalchman, M. (2011). Using the math in everyday life to improve student learning. *Middle School Journal*, *43*(1), 24–31. http://dx.doi.org/10.1080/00940771.2011.11461790

Kang, Y., & Harring, J. R. (2012). Investigating the impact of non-normality, effect size, and sample size on two-group comparison procedures: An empirical study. Paper Presented at the annual meeting of the American Educational Research Association, Vancouver, British Columbia.

Kapp, K. M. (2012). Games, gamification, and the quest for learner engagement. *T + D, 66*(6), 64-68.

Ke, F., Xie, K., & Xie, Y. (2016). Game-based learning engagement: A theory and data driven exploration. *British Journal of Educational Technology*, *47*(6), 1183–1201.

Kebritchi, M., Hirumi, A., & Bai, H. (2010). The effects of modern mathematics computer games on mathematics achievement and class motivation. *Computers & Education, 55*(2), 427–443. http://dx.doi.org/10.1016/j.compedu.2010.02.007

Kelley, D. R., Snoek, J., & Rinn, J. L. (2016). Basset: Learning the regulatory code of the accessible genome with deep convolutional neural networks. *Genome Research, 26*(7), 990-999. http://dx.doi.org/10.1101/gr.200535.115

Kim, S., & Chang, M. (2010). Computer games for the math achievement of diverse students. *Journal of Educational Technology & Society, 13*(3), 224-n/a.

Kim, S., Chang, M., Deater-Deckard, K., Evans, M. A., Norton, A., & Samur, Y. (2017). Educational games and students' game engagement in elementary school classrooms. *Journal of Computers in Education, 4*(4), 395-418. http://dx.doi.org/10.1007/s40692-017-0095-4

Kim, M. K., Roh, I. S., & Cho, M. K. (2016). Creativity of gifted students in an integrated math-science instruction. *Thinking Skills and Creativity, 19*, 38–48. http://dx.doi.org/10.1016/j.tsc.2015.07.004

Kirk, R. E. (2013). *Experimental design: Procedures for the behavioral sciences*. Thousand Oaks: Sage.

Kothari, C. R. (2008). *Research methodology methods and techniques* (2nd ed.). New Delhi, ID: New Age International.

Ku, O., Chen, S. Y., Wu, D. H., Lao, A. C. C., & Chan, T. (2014). The effects of game-based learning on mathematical confidence and performance: High ability vs. low ability. *Journal of Educational Technology & Society, 17*(3), 65–78.

Kuster, M. (2013). Applying the Welch-Satterthwaite formula to correlated errors. *NCSLI Measure, 8*(1), 42-55. http://dx.doi.org/10.1080/19315775.2013.11721629

Labaree, R. V. (2009). *Research guides: Organizing your social sciences research paper: Quantitative methods.* University of Southern California. Retrieved from http://libguides.usc.edu/writingguide/quantitative.

Laski, E. V., & Siegler, R. S. (2014). Learning from number board games: You learn what you encode. *Developmental Psychology*, *50*(3), 853–864. http://dx.doi.org/10.1037/a0034321

Lee, A. (2012). The effects of computer-based learning activities and school contextual factors on student math achievement. *Leadership and Policy Quarterly*, *1*(1), 58–72.

Lennon, E., Moriarty, B., & Zivkovic, M. (2014). *Taking it to the next interface level: Advancing game design for higher education STEM applications*. Retrieved from http://dx.doi.org/10.1109/fie.2014.7044061

Lester, J. C., Spires, H. A., Nietfeld, J. L., Minogue, J., Mott, B. W., & Lobene, E. V. (2014). Designing game-based learning environments for elementary science education: A narrative-centered learning perspective. *Information Sciences*, *264*, 4–18. http://dx.doi.org/10.1016/j.ins.2013.09.005

Levy, Y., & Ellis, T. J. (2011). A guide for novice researchers on experimental and quasi experimental studies in information systems research. *Interdisciplinary Journal of Information, Knowledge, and Management*, *6*, 151–161.

Li, M., & Tsai, C. (2013). Game-based learning in science education: A review of relevant research. *Journal of Science Education and Technology, 22*(6), 877–898. Retrieved from http://www.jstor.org.cupdx.idm.oclc.org/stable/24019764

Li, Y., & Lerner, R. M. (2013). Interrelations of behavioral, emotional, and cognitive school engagement in high school students. *Journal of Youth and Adolescence, 42*(1), 20–32. Retrieved from http://dx.doi.org.cupdx.idm.oclc.org/10.1007/s10964-012-9857-5

Lin, Y. C., Hsieh, Y. H., Hou, H. T., Yen Y. S., Chou, Y. S., & Chen, H. (2011, November). *Designing a web-based drill game to improve learners resources classification abilities: A case study.* Paper presented at the 19th International Conference on Computers in Education (ICCE2011), Chiang Mai, Thailand

Lisciandro, J. J., Jones, A., & Geerlings, P. (2018). Enabling learners starts with knowing them: Student attitudes, aspiration and anxiety towards science and math learning in an Australian pre-university enabling program. *Australian Journal of Adult Learning, 58*(1), 13-40.

Liu, E. Z., & Chen, P. (2013). The effect of game-based learning on students' learning performance in science learning—A case of "Conveyance Go." *Procedia-Social and Behavioral Sciences, 103*(26), 1044–1051.

Liu, L., Yip, S. W., Zhang, J. T., Wang, L. J., Shen, Z. J., Liu, B., et al. (2016). Activation of the ventral and dorsal striatum during cue reactivity in internet gaming disorder. *Journal of Pharmacology and Experimental Therapists, 334,* 199–205. http://dx.doi.org/10.1111/adb.12338

Loh, C. S. (2012). Information trails: In process assessment of game-based learning. In D. Ifenthaler, D. Eseryel, & X. Ge (Eds.), *Assessment in game-based learning*: *Foundations, innovations, and perspectives* (pp. 123-144). http://dx.doi.org/10.1007/978-1-4614-3546-4_8

Lopez, L. (2008). *Helping at-risk students solve mathematical word problems through the use of direct instruction and problem solving strategies* (Doctoral dissertation, University of Central Florida, Orlando, Florida).

Maclellan, E. (2013). How might teachers enable learner self-confidence? A review study. *Educational Review*, *66*(1), 59–74. http://dx.doi.org/10.1080/00131911.2013.768601

Magnuson, K. W. (2008). *Steady gains and stalled progress: Inequality and the black-white test score gap*. New York, NY: Russell Sage Foundation.

Magnuson, K. W., &, Waldfogel, J. (2008). *Steady gains and stalled progress: Inequality and the black-white test score gap*. New York, NY: Russell Sage Foundation.

Mangiante, E. M. (2010). Teachers matter: Measures of teacher effectiveness in low-income minority schools. *Educational Assessment, Evaluation and Accountability*, *23*(1), 41-63. http://dx.doi.org/10.1007/s11092-010-9107-x

Marczyk, G.R.D., DeMatteo, D. and Festinger, D. (2010). *Essentials of research design and methodology*. NY: John Wiley and Sons.

Marsh, H. W., & Scalas, L. F. (2011). Self-concept in learning: Reciprocal effects model between academic self-concept and academic achievement. In S. Järvelä (Ed.), *Social and emotional aspects of learning* (pp. 191-198). England: Oxford Academic Press.

Martin, R., Cohen, J. W., & Champion, D. R. (2013). Conceptualization, operationalization, construct validity, and truth in advertising in criminological research. *Journal of Theoretical & Philosophical Criminology*, *5*(1), 1–38.

Mata, M. D. L., Monteiro, V., & Peixoto, F. (2012). Attitudes towards mathematics: Effects of individual, motivational, and social support factors. *Child Development Research*, *1*(1), 1–10. http://dx.doi.org/10.1155/2012/876028

Mathewson, T. G. (2016). *Harvard research finds positive results from Dreambox adaptive learning.* Retrieved from http://www.educationdive.com/news/harvard-research-finds-positive-results-from-dreambox-adaptive-learning/420471/.

Mayer, I., Bekebrede, G., Harteveld, C., Warmelink, H., Zhou, Q., Ruijven, T. V., . . . Wenzler, I. (2013). The research and evaluation of serious games: Toward a comprehensive methodology. *British Journal of Educational Technology, 45*(3), 502-527. http://dx.doi.org/10.1111/bjet.12067

Mazza, J. T. (2015). *The relationship between video-based instruction and student achievement in an online math course* (Doctoral dissertation, Capella University).

McDonald, J. H. (2009). *Handbook of biological statistics*. Baltimore, MD: Sparky House Publishing.

McNeal, M. (2016). *Game-based learning has practice applications for nontraditional students.* EdSurge. Retrieved from https://www.edsurge.com/news/2016-01-20-game based-learning-has-practical-applications-for-nontraditional-learners

Mega, C., Ronconi, L., & Beni, R. D. (2014). What makes a good student? How emotions, self-regulated learning, and motivation contribute to academic achievement. *Journal of Educational Psychology, 106*(1), 121-131. http://dx.doi.org/10.1037/a0033546

Mertens, D. M. (2010). *Research and evaluation in education and psychology: Integrating diversity with quantitative, qualitative, and mixed methods*. Los Angeles, CA: Sage.

Mesoudi, A. (2017). *Nature and development of mathematics—Cross disciplinary perspectives on*. Los Angeles, CA: Taylor & Francis.

Miller, D., Robertson, D., Hudson, A., & Shimi, J. (2012). Signature pedagogy in early years' education: A role for cots game-based learning. *Computers in the Schools*, *29*(1–2), 227–247. http://dx.doi.org/10.1080/07380569.2012.651423

Mittag, K., Taylor, S., Fies, D., Johnson, G., & Dogbey, J. (2010). Mathematical explorations: Mean, median, or mode: Which one is my pencil? *Mathematics Teaching in the Middle School, 15*(9), 548-553. Retrieved from http://www.jstor.org.cupdx.idm.oclc.org/stable/41183118

Mokmin, N. A., & Masood, M. (2015). The development of self-expressive learning material for algebra learning: An inductive learning strategy. *Procedia-Social and Behavioral Sciences, 197,* 1847-1852. http://dx.doi.org/10.1016/j.sbspro.2015.07.245

Moore, J. (2011). Behaviorism. *The Psychological Record, 61*(3), 449–463 Retrieved from https://doi-org.cupdx.idm.oclc.org/10.1007/BF03395771

Moyle, K. (2010). Building innovation: Learning with technologies. *Australian Education Review, 56.* Retrieved from https://research.acer.edu.au/cgi/viewcontent.cgi?article=1009&context=aer

Mustafa, J., Khan, A., & Ullah, A. (2011). Investigating student's achievement in mathematics through non technological game-based teaching. *International Journal of Scientific Research in Education*, *4*(4), 151–164.

Myers, J. L., Well, A. D., & Lorch, R. F., Jr. (2010). *Research design and statistical analysis* (3rd ed.). New York, NY: Routledge.

Naik, N. (2017). The use of GBL to teach mathematics in higher education. *Innovations in Education and Teaching International, 54*(3), 238–246.

Nakamura, J., & Csikszentmihalyi, M. (2014). The concept of flow. In M. Csikszentmihalyi (Ed.), *Flow and the foundations of positive psychology* (pp. 239-263). Chicago, IL: Springer. http://dx.doi.org/10.1007/978-94-017-9088-8_16

Nasir, N. S. (2016). Why should mathematics educators care about race and culture? *Journal of Urban Mathematics Education*, *9*(1), 7–18.

Nesbitt, K. T., Baker-Ward, L., & Willoughby, M. T. (2013). Executive function mediates socio-economic and racial differences in early academic achievement. *Early Childhood Research Quarterly*, *28*(4), 774-783. http://dx.doi.org/10.1016/j.ecresq.2013.07.005

Organization for Economic Cooperation and Development (OECD). (2013). *PISA 2012 results: Excellence through equity: Giving every student the chance to succeed* (Vol. II). Paris, France: OECD Publishing. http://dx.doi.org/10.1787/9789264201132-en

Oliver, K., Kennedy, K., Hibbard, L., Swan, B., Clark, T., Lafrance, J., & Oglesby, J. (2015). Personalization of learning: Lessons from RTT-D winners. *ELearn*, 1. http://dx.doi.org/10.1145/2822373.2816976

Oliver, P. (2010). *Understanding the research process*. Los Angeles, CA: Sage.

Ostrosky, M. M., & Meadan, H. (2010). Helping children play and learn together. *Young Children*, *65*(1), 104-108, 110.

Panoutsopoulos, H., & Sampson, D. G. (2012). A study on exploiting commercial digital games into school context. *Journal of Educational Technology & Society*, *15*(1), 15-n/a.

Park, A. Y. (2015). Development of a language learners' reading fluency test with regard to pre/post test design. *Asia-Pacific Journal of Multimedia Services Convergent with Art, Humanities, and Sociology*, *5*(5), 361-370. http://dx.doi.org/10.14257/ajmahs.2015.10.48

Park, D., Gunderson, E. A., Tsukayama, E., Levine, S. C., & Beilock, S. L. (2016). Young children's motivational frameworks and math achievement: Relation to teacher-reported instructional practices, but not teacher theory of intelligence. *Journal of Educational Psychology*, *108*(3), 300.

Park, S., & Yun, H. (2018). The influence of motivational regulation strategies on online students' behavioral, emotional, and cognitive engagement. *American Journal of Distance Education, 32*(1). http://dx.doi.org/10.1080/08923647.2018.1412738

Parrett, W. H., & Budge, K. M. (2012). *Turning high-poverty schools into high-performing schools*. Alexandria, VA: Association for Supervision & Curriculum Development.

Piontek, J. (2013). *Introduction to blended learning for elementary schools.* Retrieved from http://www-static.dreambox.com/wp-content/uploads/2013/02/white-paper-introduction-to-blended-learning-for-elementary-schools.pdf.

Pitt, M. B., Borman-Shoap, E. C., & Eppich, W. J. (2015). Twelve tips for maximizing the effectiveness of game-based learning. *Medical Teacher*, *37*(11), 1013–1017. http://dx.doi.org/10.3109/0142159X.2015.1020289

Plass J. L., Homer B. D., & Kinzer C. K. (2015). Foundations of game-based learning. *Educational Psychologist, 50*(4), 258–283. http://dx.doi.org/10.1080/00461520.2015.1122533

Qian, M., & Clark, K. R. (2014). Game-based learning and 21st century skills: A review of recent research. *Computers* in *Human* Behavior, *63*, 50-58. http://dx.doi.org/10.1016/j.chb.2016.05.023

Quirmbach, L. M., Lincoln, A. J., Feinberg-Gizzo, M. J., Ingersoll, B. R., & Andrews, S. M. (2009). Social stories: Mechanisms of effectiveness in increasing game play skills in children diagnosed with autism spectrum disorder using a pretest posttest repeated measures randomized control group design. *Journal of Autism and Developmental Disorders*, *39*(2), 299–321.

Raies, K., Khernaja, M., & Braham, R. (2013). Towards game based learning design process based on semantic service oriented architecture (SSOA). Presented at the 7th European Conference on Games Based Learning. *European Conference on Games, 2*, 698-705.

Razza, R. A., Martin, A., & Brooks-Gunn, J. (2012). The implications of early attentional regulation for school success among low-income children. *Journal of Applied Developmental Psychology*, *33*(6), 311-319. http://dx.doi.org/10.1016/j.appdev.2012.07.005

Reardon, S. (2013). The widening income achievement gap. *Educational Leadership*, *70*(8), 10-16.

Reeve, J., & Lee, W. (2014). Students' classroom engagement produces longitudinal changes in classroom motivation. *Journal of Educational Psychology, 106*(2), 527-540. Retrieved from http://dx.doi.org.cupdx.idm.oclc.org/10.1037/a0034934

Reyes, M. R., Brackett, M. A., Rivers, S. E., White, M., & Salovey, P. (2012). Classroom emotional climate, student engagement, and academic achievement. *Journal of Educational Psychology*, *104*(3), 700–712. http://dx.doi.org/10.1037/a0027268

Rockwell, S. K., & Kohn, H. (1989, Summer). Post-then-pre evaluation. *Journal of Extension* [On-line], *27*(2). Available at http://www.joe.org/joe/1989summer/a5.html

Ronimus, M., Kujala, J., Tolvanen, A., & Lyytinen, H. (2014). Children's engagement during digital game-based learning of reading: The effects of time, rewards, and challenge. *Computers & Education, 71*, 237–246.

Rookhuiszen, R. B., & Theune, M. (2009). Playful vs. serious instruction giving in a 3D game environment. *Entertainment Computing, 1*(2), 95-104. http://dx.doi.org/10.1016/j.entcom.2009.09.006

Ruiz-Gallardo, J.-R., Verde, A., & Valdés, A. (2013). Garden-based learning: An experience with "at risk" secondary education students. *The Journal of Environmental Education, 44*(4), 252–270. http://dx.doi.org/10.1080/00958964.2013.786669

Sabourin, J. L., & Lester, J. C. (2014). Affect and engagement in game-based learning environments. *IEEE Transactions on Affective Computing, 5*(1), 45–56.

Sallee, M., & Flood, J. T. (2012). Using qualitative research to bridge research, policy, and practice. *Theory Into Practice, 51*(2), 137-144. http://dx.doi.org/1080/00405841.2012.662873

Schaaf, R. (2012). Does digital game-based learning improve student time-on-task behaviour and engagement in comparison to alternative instructional strategies? *The Canadian Journal of Action Research, 13*(1), 50–64.

Sengupta-Irving, T., & Enyedy, N. (2014). Why engaging in mathematical practices may explain stronger outcomes in affect and engagement: Comparing student-driven with highly guided inquiry. *Journal of the Learning Sciences, 24*(4), 550-592. http://dx.doi.org/10.1080/10508406.2014.928214

Sevecke, J. R. (2015). Test review: Test of mathematical abilities. *Journal of Psychoeducational Assessment*, *32*(6), 581-584. http://dx.doi.org/10.1177/0734282914526013

Shadish, W. R., & Galindo, R. (2010). Quasi-experimental design. *The Corsini encyclopedia of psychology*. http://dx.doi.org/10.1002/9780470479216.corpsy0765

Sharek, D., & Wiebe, E., (2011). Using flow theory to design video games as experimental stimuli. *Sage Journals*, *55*(1), 1520-1524. Retrieved from https://doi-org.cupdx.idm.oclc.org/10.1177/1071181311551

Shernoff, D. J., Ruzek, E. A., & Sinah, S. (2016). The influence of the high school classroom environment on learning as mediated by student engagement. *School Psychology International*, *1*(18), 1–18. http://dx.doi.org/10.1177/0143034316666413

Sheskin, D. J. (2011). *Handbook of parametric and nonparametric statistical procedures* (5th ed.). Boca Raton, FL: Chapman & Hall/CRC Press.

Shih, J. L., Jheng, S. C., & Tseng, J. J. (2015). A simulated learning environment of history games for enhancing players' cultural awareness. *Interactive Learning Environments*, *23*(2), 191–211. http://dx.doi.org/10.1080/10494820.2014.997249

Shin, N., Sutherland, L. M., Norris, C. A., & Soloway, E. (2012). Effects of game technology on elementary student learning in mathematics. *British Journal of Educational Technology*, *43*(4), 540–560. Retrieved from http://dx.doi.org.cupdx.idm.oclc.org/10.1111/j.14678535.2011.01197.x

Simões, J., Redondo, R. D., & Vilas, A. F. (2013). A social gamification framework for a K-6 learning platform. *Computers in Human Behavior*, *29*(2), 345–353.

Smaldino, S. E. (2011). Preparing students with 21st century ICT literacy in math and science education. *Journal of Curriculum and Instruction*, *5*(1), 1–3. http://dx.doi.org/10.3776/joci.2011.v5n1p1-3

Smeda, N., Dakich, E., & Sharda, N. (2014). The effectiveness of digital storytelling in the classrooms: A comprehensive study. *Smart Learning Environments*, *1*(1), 6.

Spires, H. A., & Lester, J. C. (2016). Game-based learning: Creating a multidisciplinary community of inquiry. *On the Horizon*, *24*(1), 88–93.

Stacy, S. T., Cartwright, M., Arwood, Z., Canfield, J. P., & Kloos, H. (2017). Addressing the math-practice gap in elementary school: Are tablets a feasible tool for informal math practice? *Frontiers in Psychology, 8*, 1–12. http://dx.doi.org/10.3389/fpsyg.2017.00179

Stake, R. E. (2010). *Qualitative research: Studying how things work*. New York, NY: The Guilford Press.

Stanescu, I. A., Stefan, A., Hauge, B. (2016, September 28-30). Using gamification mechanisms and digital games in structured and unstructured learning contexts. In G. Wallner, S. Kriglstein, H. Hlavacs, R. Malaka, A. Lugmayr, & H. S. Yang (Eds.), *Entertainment Computing – ICEC 2016*. Wien, Austria: Springer, Cham.

Steffens, M. C., Jelenec, P., & Noack, P. (2010). On the leaky math pipeline: Comparing implicit math-gender stereotypes and math withdrawal in female and male children and adolescents. *Journal of Educational Psychology*, *102*(4), 947.

Stern, R. (2012). Constructivism and the argument from autonomy. *Constructivism in Practical Philosophy*, 119-137. http://dx.doi.org/10.1093/acprof:oso/9780199609833.003.0007

Stigler, S. (2008). Fisher and the 5% level. *Chance*, *21*(4), 12.

Song, I., & Jeong, H. (2015). Effects of emergency nursing simulation-based education program for self-directed learning ability and confidence in performance. *Journal of Educational Technology & Society, 103*, 146-150. http://dx.doi.org/10.14257/astl.2015.103.32

Su, C., & Cheng, C. (2014). A mobile gamification learning system for improving the learning motivation and achievements. *Journal of Computer Assisted Learning*, *31*(3). http://dx.doi.org/10.1111/jcal.12088

Suitts, S. (2015). A new majority: Low income students now a majority in the nation's public schools. *Southern Education*. Retrieved from http://www.southerneducation.org/

Sun, C., Chen, L., & Chu, H. (2018). Associations among scaffold presentation, reward mechanisms and problem-solving behaviors in game play. *Computers & Education*, *119*, 95-111. http://dx.doi.org/10.1016/j.compedu.2018.01.001

Sweet. S., & Martin. K. (2012). *Data analysis with SPSS: A first course in applied statistics* (4th ed.). New York: NY: Allyn and Bacon.

Tanes, Z., & Cho, H. (2013). Goal setting outcomes: Examining the role of goal interaction in influencing the experience and learning outcomes of video game play for earthquake preparedness. *Computers in Human Behavior, 29*(3), 858-869. http://dx.doi.org/10.1016/j.chb.2012.11.003

Thayer, B. A. (2012). The role of group research designs to evaluate social work practice. *Quasi-experimental research designs* (pp. 77-106). http://dx.doi.org/10.1093/acprof:oso/9780195387384.003.0003

Tobias, S., Fletcher, J. D., & Wind, A. P. (2014). Game-based learning. In *Handbook of research on educational communications and technology* (pp. 485–503).New York, NY: Springer.

Trust, T. (2017). Preparing future teachers to redefine learning with technology. *Journal of Digital Learning in Teacher Education, 33*(2), 44-45. http://dx.doi.org/10.1080/21532974.2017.1281654

Vanneman, A., Hamilton, L., Anderson, J. B., & Rahman, T. (2009). *Achievement gaps: How black and white students in public schools perform in mathematics and reading on the National Assessment of Educational Progress* (NCES 2009-455). Washington, DC: National Center for Education Statistics, Institute of Education Sciences, U.S.

Department of Education. Retrieved from http://nces.ed.gov/nationsreportcard/pdf/studies/2009455.pdf

Viale, R. (2012). *Methodological cognitivism.* http://dx.doi.org/10.1007/978-3-642-24743-9

Villalon, J. J. (2016). Lesson study: Its influence on planning, instruction, and self-confidence of pre-service mathematics teachers. *US-China Education Review B, 6*(7). http://dx.doi.org/10.17265/2161-6248/2016.07.003

Vrugte, J., De Jong, T., Vandercruysse, S., Wouters, P., Van Oostendorp, H., & Elen, J. (2015). How competition and heterogeneous collaboration interact in prevocational game-based mathematics education. Oxford, UK: Elsevier Science.

Wang, J.-H., Chen, S. Y., & Chan, T.-W. (2016). An investigation of a joyful peer response system: High ability vs. low ability. *International Journal of Human-Computer Interaction*, *32*(6), 431–444. http://dx.doi.org/10.1080/10447318.2016.1159800

Watson, J. B. (2013). *Behaviorism* (6th ed.). Charlotte, NC: Information Age Pub.

Watson, R. (2015). Quantitative research. *Nursing Standard, 29*(31), 44. Retrieved from http://dx.doi.org.cupdx.idm.oclc.org/10.7748/ns.29.31.44.e8681

Weigel, M. (2013). *Outcomes of game-based learning: Research roundup journalist's resource.* Journalists' Resource. Retrieved from http://journalistsresource.org/studies/society/education/outcomes-of-game-based-learning-research-roundup

Weinstein, M. G., Stiefel, L., Schwartz, A. E., & Chalico, L. (2009*). Does Title I increase spending and improve performance? Evidence from New York City* (Working Paper# 09-09). New York, NY: Institute for Education and Social Policy.

Whitton, N. (2011). Encouraging engagement in game-based learning. *International Journal of Game-Based Learning*, *1*(1), 75-84. http://dx.doi.org/10.4018/ijgbl.2011010106

Whitton, N. (2012). The place of game-based learning in an age of austerity. *Electronic Journal of E-learning*, *10*(2), 249–256.

Wilcox, R. R. (2012). *Introduction to robust estimation and hypothesis testing* (3rd.ed.). Cambridge, MA: Academic Press.

Williams, D. R., Brule, H., Kelley, S. S., & Skinner, E. A. (2018). Science in the Learning Gardens (SciLG): A study of students' motivation, achievement, and science identity in low-income middle schools. *International Journal of STEM Education, 5*(1). http://dx.doi.org/10.1186/s40594-018-0104-9

Woo. (2014). Digital game-based learning supports student motivation, cognitive success, and performance outcomes. *Journal of Educational Technology & Society*, *17*(3), 291–307.

Wu, W. H., Hsiao, H. C., Wu, P. L., Lin, C. H., & Huang, S. H. (2012). Investigating the learning-theory foundations of game-based learning: A meta-analysis. *Journal of Computer Assisted Learning*, *28*, 265–279. http://dx.doi.org/10.1111/j.1365-2729.2011.00437.x

Ya-Ting, C. Y. (2012). Building virtual cities, inspiring intelligent citizens: Digital games for developing students' problem solving and learning motivation. *Computers and Education*, *59*(2), 365–377.

Yilmaz, K., (2011). The cognitive perspective on learning: Its theoretical underpinnings and implications for classroom practices. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas, 84*(5), http://dx.doi.org/10.1080/00098655.2011.568989

Yin, R. K., & Campbell, D. T. (2018). *Case study research and applications: Design and methods*. Thousand Oaks, CA: Sage.

Yong, Z, (2010). Preparing globally competent teachers: A new imperative for teacher education. *Journal of Teacher Education*, *61*(5), 422-431. http://dx.doi.org/10.1177/0022487110375802.

Zhang, M. (2015). Understanding the relationships between interest in online math games and academic performance. *Journal of Computer Assisted Learning*, *31*(3), 254–267.

Zhao, W., Weng, Y., Wu, Q., & Palesch, Y. (2011). Quantitative comparison of randomization designs in sequential clinical trials based on treatment balance and allocation randomness. *Pharmaceutical Statistics*, *11*(1), 39-48. http://dx.doi.org/10.1002/pst.493

Zientek, L., Nimon, K., & Hammack-Brown, B. (2016). Analyzing data from a pretest-posttest control group design. *European Journal of Training and Development*, *40*(8/9), 638-659. http://dx.doi.org/10.1108/ejtd-08-2015-0066

Appendix A: Statement of Original Work

I attest that:

1. I have read, understood, and complied with all aspects of the Concordia University-Portland Academic Integrity Policy during the development and writing of this dissertation.

2. Where information and/or materials from outside sources has been used in the production of this dissertation, all information and/or materials from outside sources has been properly referenced and all permissions required for use of the information and/or materials have been obtained, in accordance with research standards outlined in the *Publication Manual of The American Psychological Association.*

_
Digital Signature

LaDonna Martin
Name (Typed)

_May 30, 2018________
Date