The Effect of Digital Game-Based Learning on Students' Motivation in Math Classes

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ABSTRACT

THE EFFECT OF DIGITAL GAME-BASED LEARNING ON STUDENTS' MOTIVATION IN MATH CLASSES

Department of Educational Technology, Research and Assessment
Northern Illinois University, 2021
Fatih Demir, Director

Students often see mathematics as a hard subject because they have to rely on logic, mathematical theories of equations, proofs, and some of math concepts that are difficult to understand, which contributes to students’ poor performance and low motivation to learn math. Therefore, the purpose of this quantitative study was to investigate the effects of using digital math games on fourth-grade elementary students' motivation to learn math in Saudi Arabia. This study also focused on the effects of gender differences on their motivation to learn math. Data for this quasi-experimental study were collected from 200 students using a pre- and post-survey questionnaire for two groups: control group and treatment group for both genders (boys and girls). The results show a statistically significant gender difference in motivation scores among boys and girls, where boys scored higher than girls in both the group who used a digital math game and the group who did not use it. However, the results of the effect of using digital math games on fourth-grade students' motivation was not significant, indicating that the math games did not provide a significant contribution to increasing students' motivation towards learning math.
NORTHERN ILLINOIS UNIVERSITY
DEKALB, ILLINOIS

MAY 2021

THE EFFECT OF DIGITAL GAME-BASED LEARNING ON STUDENTS' MOTIVATION IN MATH CLASSES

BY
RANIA ABDULKAREEM KOKANDY

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A DISSERTATION SUBMITTED TO THE GRADUATE SCHOOL
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE
DOCTOR OF PHILOSOPHY

DEPARTMENT OF EDUCATIONAL TECHNOLOGY, RESEARCH AND ASSESSMENT

Doctoral Director:
Fatih Demir
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DEDICATION

I dedicate this dissertation to my beautiful family: my parents, my brother, and my sisters for everything they have done and for their prayers and support throughout my learning process.
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CHAPTER 1
INTRODUCTION

The current era of technology has changed the way individuals live, think, and interact with others in our environment. New and emerging technologies such as “digital games” have permeated children’s and adolescents’ daily lives (Hong et al., 2009). The use of digital gaming has become more common among young people and it is prevalent in the lives of American teens. Findings from the Pew Internet and American Life Project showed that 97% of 12 to 17-year-old individuals play digital games daily (Lenhart, Kahne, Middaugh, Macgill, Evans, & Vitak, 2008), whether on computers, consoles or hand-held devices (Sardone & Devlin-Scherer, 2009).

The first development of computer games occurred in the late 1960s. In the 1970s, the primary idea of integrating games into the learning process was established; however, the decision makers at the Department of Education did not have any initiatives about applying digital games into the classroom (Noraddin & Kian, 2014). The 1980s witnessed a rebound for the gaming industry in various forms on consoles, computers, or hand-held devices. However, there were tremendous advances to produce extremely sophisticated software applications for digital games that could support teaching and learning. So the idea of using digital games in teaching in the educational sector has become popular since the 1990s, leading to the first significant revolution in the field of academic research into digital games (Habgood, 2007). As a result, this new technology aroused the curiosity and enthusiasm of researchers investigating the
power beyond using digital games in learning environments (Noraddin, & Kian, 2014). Since the turn of the millennium, digital games have become extremely popular and attractive to all ages of kids, teenagers, and adults (Zin, Jaafar, & Yue, 2009). In recent years gaming has become a widespread activity in our society; more than 45 million homes have video game consoles (Jinapriya, 2016). This popularity of the use of digital games-based learning leads to increased further attention from educators to recruit them in education (Cheng & Su, 2012). Also, Noraddin and Kian (2014) reported soon upcoming generations will heavily depend on using digital games for educational purposes. Consequently, academic institutions are trying to incorporate educational games into schools and universities to facilitate teaching.

In 2013, the National Assessment of Educational Progress (NAEP) reported that 18% of U. S 4th grade students had difficulty understanding basic mathematics content (National Center for Education Statistics, 2013). Also, as Mullis, Martin, Foy, and Arora (2012) indicated, American students who are only in Grades 4 and 8 dislike learning mathematics. Similarly, the number of Australian students taking advanced mathematics has fallen rapidly, from 14.1% to 11.7% in 2004 (Barrington, 2006). In this light, Noraddin and Kian (2015) investigated the effect of using game-based learning to enhance the learning process in math. They found that math games were an effective tool for supporting students’ learning in that students were able to interact with real-world simulations to solve real problems, learn new math skills, and acquire new knowledge.

Digital Games and What They Do

The term “digital games” generally refers to an electronic game in the form of a computer, a console, or a cell phone that has animations on a video or computer
These digital games can be controlled by users following some rules and instruction to reach certain goals (Felicia, 2011). Also, Frederick (2009) defined digital games as "a methodology that may hold special appeal to students who grew up in recent years with the explosion of digital games" (p. 3). In other words, digital games can be used in an educational environment to serve learning and teaching processes; this is known as digital games-based learning, which is specifically designed for learning purposes. Digital games-based learning involves ideal learning devices that are built to focus on supporting learning and helping students to develop their skills in communication, problem solving, creative thinking, and decision making when learners are playing games (Noraddin & Kian, 2015). In addition, these games are characterized by a combination of numerous unique characteristics such as visual images, entertainment, gameplay, rules, objectives, feedback, competitiveness among users, challenges, and social interaction.

The prevalence of digital games-based learning in schools among elementary and middle school students is growing and has captured the interest of many young people and adults (Kraus, 1982). Moreover, as students of this generation are already interested and attracted to games, most educators see that they can easily harness digital games within instructional activities for teaching tough subjects such as science, technology, engineering, and mathematics (STEM; Cheng & Su, 2012). This will also facilitate learning these difficult subjects and positively affect students’ academic performance (Tella, 2007). As a result, the technique of integrating digital games will develop traditional learning environments that lead to changes in the roles of both instructors and students (Noraddin & Kian, 2014). Instructors will no longer simply transfer and deliver information, but they will also guide students in the learning process as well as create student-centered learning. Educators might use this medium as an adjunct in the
class to teach certain concepts, subjects, and complex terms introduced during formal classes to motivate students to learn, give them the opportunity to apply knowledge they have learned, and practice some skills frequently until they become proficient (Huizenga et al., 2009). A study conducted by Chung and Chang (2017) on the incorporation of digital games in teaching difficult subjects revealed that this method is mostly suitable for these kinds of subjects because students usually lack motivation toward learning these subjects.

The Problem Statement

The General Administration of Educational Supervision in the Kingdom of Saudi Arabia (KSA) reported low performance in math among students at all grade levels in Saudi Arabian schools (Ministry of Education, 2007). In addition, the results of the Trends of International Mathematics and the Science Study (TIMSS) that evaluated students' performance in mathematics in 2011 demonstrated that the fourth-grade students in the KSA earned low achievement scores (an average of 410 out of a possible 500) in mathematics. The problem of low performance in learning mathematics still remains one of the major problems in Saudi Arabian schools (Alreshidi, 2016). Reasons can be attributed to the problem of learning math from textbooks in a purely abstract form, thereby not building math skills that students need, such as critical analysis, problem solving, and decision making (Khormi & Woolner, 2019). Also, the conventional methods of teaching are based on memorization of the content without giving students a chance to be creative in how they learn to apply mathematics concepts and develop math skills (Almaleki, 2010).

There is a lack of and innovative methods for teaching math and little use of educational technology tools that enhance students’ learning in the education process (Almaleki, 2010). As
Alreshidi, (2016) reported, that most students in the KSA face difficulties in learning math because of a lack of understanding of mathematics concepts and theories of equations. Thus, this contributes to students' poor performance with low motivation to learn math. Usher and Kober (2012) indicated that loss of motivation to learn math is a real problem and leads to decreased academic achievement over time because students were unmotivated to learn (Bridgeland, Dilulio, & Morison, 2006).

Moreover, in general, mathematics is the science of abstract mathematical concepts that rely on using logic, mathematical theories of equations, and proofs. Behind this basic knowledge of understanding mathematics is a complex structure of rules, concepts, and procedures (Heins, 2017). Mathematics courses usually require high levels of thinking, reasoning, and problem-solving skills (Jones, 2015) and many students lack those skills and feel powerless in their abilities to solve mathematical problems. Students recognize that math is a hard subject because the visual representation of the math concepts such as decimals or fractions cannot provide understanding of the true meaning of those concepts (Beres, 2011). As a result, they must memorize mathematical equations, facts, and concepts in the textbook (Beres, 2011).

Learning math is a challenging problem, and as Suarsana, Lestari, and Mertasari (2019) assert, math is based on problem-solving ability and this ability is crucial in mathematics learning. This capability requires the coherence of four steps: thorough understanding of the problem, developing a plan, implementing the plan, and solving the problem. The students who are not familiar with this process of problem solving cannot master this skill and are likely to fail in math. For this reason, the nature of mathematics leads students to struggle to understand mathematical equations, so they see it is a boring and difficult subject (Nelson-Walker, Doabler, Fien, Gause, Baker, & Clarke, 2013). As a result, some students form negative views of math
and they still hold that opinion because of a lack of understanding of mathematics content. Math is the most difficult subject to increase students' motivation, and developing motivational strategies can be challenging for teachers (Jones, 2015). Consequently, when students have low motivation, teachers face a real problem in the classroom. Thus, it is important to increase students' motivation and interest in math courses. It is clear that mathematics has become a focal issue that should be addressed. What then is the solution?

Nelson-Walker et al. (2013) reported that students who had performed poorly in mathematics at an early age will continue to struggle during high school. To address this problem, they suggested a strategy for resolving this issue that was aimed at motivating students and increasing their proficiency to succeed in math. This strategy was using educational math games in the classroom as a supplementary tool for teaching math to support these students. The findings showed that participating students of K-2 grades expressed they were enthusiastic to demonstrate their proficiency while playing the games. The games rapidly increased their motivation and raised their academic performance level in mathematics while soothing their feelings of frustration at frequently failing in solving math problems. Moreover, Maloy, Edwards, and Anderson (2010) examined games in math class; 125 students in fourth grade used computer math games (Rainforest Maths) and math board games called Qwirkle on interactive educational websites to learn mathematical problem-solving skills. Based on Maloy et al.'s findings, they concluded that math games were valuable in learning math as students demonstrated growth in performance scores. In addition, games supported students’ creative writing in math problem solving where they were acting as problem solvers.

Furthermore, Salminen, Koponen, Räsänen, and Aro (2015) conducted a study on kindergarteners who are most at risk for mathematics difficulties (MD). They examined the
effects of two mathematical computer games, GraphoGame Math (GGM) and Number Race (NR), on each early number skill (verbal counting, subitizing fluency, dot counting fluency and basic arithmetic) in kindergarten students. The results indicated that math games had a positive effect; there were improvements in verbal counting and dot counting fluency. Children demonstrated proficiency in dot counting after they used the GGM game and they significantly improved basic arithmetic skill after playing NR game. In the same manner, Noraddin and Kian (2015) confirmed that math game-based learning is an effective tool for enhancing the learning process in math, where students as players can interact with real-world simulations to solve real problems, learn skills, add knowledge, and incorporate values in an authentic environment.

Despite all these confirmations of the effectiveness of digital games and their potential advantages, games still may not be the empowering tool to teach hard subjects or may not be designed well enough to address all cases (Aljaraideh, 2014). There is a dearth of mathematics games that teach new and complex concepts, thus failing to give students practice at solving and encountering them and not enabling student learning. Also, many of these games fail to teach proper math terminology or provide clear instruction (Nelson-Walker et al., 2013). Pareto, Haake, Lindstrom, Sjoden and Gulz (2012) argued that, in general, most educational games have an impact on learning and motivation, but not many games brought about skill and competency acquisition or conceptual understanding of a math subject. A few doubts exist about whether students can learn effectively from video games or not (Egenfeldt-Nielsen, 2006). Moreover, 80% of teachers indicated that digital games-based learning negatively impacted learning by causing the distraction of students in the classroom and therefore missing the instruction (McCoy, 2013). In other words, teachers believed that games that were integrated within an
instructional activity context lead to a waste of the value of both learning and enjoying the games (Aljaraideh, 2014).

Even though the aforementioned studies highlighted the learning outcomes of using math games, few have addressed the gender differences among learners (Tsai, 2017). Thus it is necessary to understand how males and females are different in gaming behavior (interaction and attitudes) towards the math game-based learning and how gender could have an effect on students' motivation.

Research has shown that gender has a critical role in shaping students’ learning motivation. In a review of previous studies on the relationship between gender and motivation, meta-analysis found that a number of researchers (Chou & Tsai, 2007; Wright et al., 2001) have studied gender differences regarding their attitudes, preferences, performance, and the number of times using digital games-based learning in general. For instance, Meece, Glienke, and Burg (2006) found that genders are different in preferred learning subjects. Boys were more highly motivated and interested in learning mathematics and science, while girls enjoyed learning language arts and writing more. As Meece et al. indicated, these differences in motivation among genders are related to their beliefs and behaviors. In addition, Riding and Grimley (1999) confirmed that males and females differ in their attitudes toward math game-based learning. Women tended to prefer exploratory and puzzle types of games and self-learning (autonomous) during play. In comparison, men favored collaborative learning when playing games that involved strategical and logical analysis and action/adventure (Chung & Chang, 2017).

Fahuzan and Santosa (2018) indicated that motivation, which can be affected by gender, is the most significant factor in stimulating students to learn mathematics. They identified a comparison between of male and female students' motivation in learning math using a
smartphone to play a role play game (RPG). The male students' motivation was significantly higher than the female students' motivation. Furthermore, they discovered integration of math games via smartphones in difficult subjects such as math was an effective way for students who had poor motivation to learn the subject. These studies show that gender has an impact on learning motivation in math game-based learning.

However, Mavridis, Katmada, and Tsiatsos (2017) reported different findings in their study comparing girls' and boys' attitudes towards solving problems by using an online flexible educational math game. They found no significant gender difference among students regarding their attitude towards mathematics. Similarly, the results showed that gender differences did not exist among boys and girls in the performance and achievement towards math. Ke and Grabowski (2007) noted that computer game playing did not show significant differences on fifth graders of two genders in math performance and achievement. Chang et al. (2016) stated similar results in their study when testing differences in math engagement among males and females of fifth-grade students who used an educational video game (APP) in mathematics classrooms. No significant difference was revealed in either gender regarding engagement levels from the pre-test to post-test, although males were somewhat higher in their level of engagement in math.

Similarly, Chung and Chang (2017) claimed that there was a lack of studies that investigate gender differences on motivation and learning achievement regarding learning and engagement. Thus, they adapted a quasi-experimental design to determine the impact of gender on motivation and learning achievements on 100 fourth-grade students from elementary school through observing the learners' engagement and learning when using the Emergency First Aid (EFA) digital game. Results showed that gender did not affect learning achievement and
motivation, which showed no significant differences between gender, although females' motivation was higher than male learners. Both genders were at a high level of engagement.

In fact, these studies have shown that no extensive gender differences exist regarding learning math results in digital game-based math learning environments and these results in previous studies suggest a need for future research. Thus, Joiner et al. (2011) recommended conducting further studies to explore whether there is a gender difference between male and female motivation in math courses when playing different types of digital games.

After reviewing the literature, I found that most empirical studies were conducted on the use of digital game-based math learning on elementary school students in developed countries, whereas there were few studies that examined the use of digital game-based math learning with elementary students in Saudi Arabian schools. In addition, empirical research has not been conducted in Saudi Arabia focusing on examining gender segregation and differences in terms of motivation for learning math in K-12 education (Alreshidi, 2016). In this regard, this gap found in the literature calls for this research to be conducted to investigate the effects of using digital game-based math learning on elementary students' motivation to learn math in Saudi Arabian schools.

Based on that, the focus of the present study addressed the gaps in empirical studies. Therefore, the current study examined how playing digital math games affected fourth-grade Saudi Arabian elementary students' motivation to learn math by focusing on gender differences between boys' and girls' motivation toward math while they play math games.
Purpose of the Study

The purpose of this study was to investigate the effects of using digital math games on fourth-grade elementary students' motivation to learn math in Saudi Arabia. This study also focused on the effect of gender differences on their motivation to learn math.

Research Questions

The current study was guided by the following questions:

1. To what extent is the use of digital math games related to elementary students' motivation to learn math?
2. To what extent does gender moderate the relationship between the use of digital math games and students' motivation to learn math?

The Significance of the Study

The significance of this study is that most existing empirical studies were conducted with elementary and middle school students in the USA, Taiwan, Turkey, and other countries, but not in the Middle Eastern countries in general or in Saudi Arabia in particular. This means that although there have been many studies conducted regarding the effectiveness of digital games-based learning in other regions, there is a lack of evidence of the use of digital games in classroom settings for elementary students in Saudi Arabia. Therefore, I decided to do this study to shed light on the importance of embracing digital games as a pedagogical tool for teaching mathematics in the Saudi Arabian elementary classroom setting.

Most importantly, digital games are not widely used in Saudi Arabian public schools but have been used formally only in a few international schools as experimental. The idea of
integrating digital games into elementary schools is a new trend in the Saudi Arabian education system. Currently, instructional designers are trying to incorporate games into teaching some subjects for the first time in the Saudi Arabian schools. Because the use of educational games is still in its infancy, there is a need for more empirical research in this area to promote this educational practice. In the same manner, this study may help teachers understand the value of using digital game-based math learning in elementary grades. Additionally, this research may provide evidence that gender separation in education enhances students' chances of academic success and creativity as well as promotes the idea of providing equal learning opportunities for females and males in Saudi Arabia.

Theoretical Framework and Construct

According to Creswell (2012), a theory in quantitative research serves as a bridge that connects the independent and dependent variables to explain the probable relationship between variables or to study the effect of the independent variable on the dependent variable (p. 120). Because this study focused on investigating the effect of the use of the IXL math game on fourth-grade students' motivation towards learning math, motivation is considered an important variable to be measured to explore whether games could be the right tool to motivate students to learn math. Motivation theories generally aim to discover what factors stimulate and drive individuals to learn when they interact with a certain situation to achieve specific goals (Hong, Cheng, Hwang, Lee, & Chang, 2009). Motivation theory includes two fundamental types of motivation: intrinsic motivation and extrinsic motivation (Eggan & Kauchak, 2004).

The theoretical framework that guided and supported this current research was intrinsic motivation theory (Ryan & Deci, 2000a). This theory was utilized to explain how students are
motivated through using digital math games. Essentially, Edward Deci and Richard Ryan had essential roles in distinguishing between the basic types of motivations. According to Ryan and Deci (2000a) philosophy, intrinsic motivation is "doing something because it is inherently interesting or enjoyable" and extrinsic motivation is "doing something because it leads to a separable outcome" (p. 55). Strictly speaking, “the intrinsic motivation of a person stems from his or her feelings of competency, personal development, and experience” (Nguyen, 2015, p. 10). Intrinsic motivation occurs when “a person feels instinctive pleasure when he/she learns something new or succeeds in a challenging task” (Palmer, 2005, p. 1858). For example, the enthusiasm of learners to play a game and attempt to achieve a specific goal is an intrinsic motivation, where they are shown to be intrinsically motivated because they intend to challenge themselves to accomplish this task or goal or to learn new knowledge without getting any reinforcement from teachers or anyone (Nguyen, 2015). Consequently, the students will be more engaged in learning activities because of feelings of confidence and satisfaction (Tuan, Chin & Shieh, 2005). In other words, this intrinsic motivation is required initially to stimulate students to participate in the complete learning process (Palmer, 2005).

According to self-determination theory (SDT), intrinsic motivation arises from three necessary internal psychological needs for the individual: competence, autonomy, and relatedness (Ryan & Deci, 2000b). When the three psychological needs are met in a classroom environment, intrinsic motivation will be increased and individuals will fully engage in activities without resistance (Wang, Liu, Kee, & Chian, 2019). However, when the three psychological needs are absent, intrinsic motivation will be decreased (Wang et al., 2019). Moller, Ryan, and Deci (2006) found that these needs influence intrinsic motivation and positively relate to enjoyment, interest, and engagement. For example, the individuals with low competence and
autonomy do not show interest in completing a particular task; thus, their engagement will be low because the tasks are not valuable to them. On the contrary, individuals who have full autonomy and competence display interest in reaching their goals, becoming more engaged in performing particular tasks (Guay, Vallerand, & Blanchard, 2000). In addition, there are motivational factors that enhance and foster intrinsic motivation, such as students’ self-confidence, positive affect, and task values (Tuan, Chin, & Shieh, 2005; Usher & Kober, 2012).

Previous studies revealed that intrinsic motivation has been used in many studies and it proved effective in studying individuals' motivation. For example, Kebritchi (2008) revealed that intrinsic motivation is proper for use when examining the relationships between an individual's motivation and use of instructional education games. Ninaus, Moeller, McMullen and Kiili (2017) indicated that intrinsic motivation was relevant to the students' success in learning math within game-based learning approaches, as their results provided evidence that students' enjoyment in playing games was one of the major indicators for the effectiveness of using math games. Additionally, Colomeischi and Colomeischi (2015) reported that learners who have high levels of enthusiasm actively engage in math activities to practice previous experiences during games, which is considered an intrinsic motivation. This finding suggested that students' intrinsic motivation is influenced by a positive affect factor. Although the positive affect is not a construct of intrinsic motivation theory, literature indicates that positive affect factor is highly related to intrinsic motivation. As Løvoll, Røysamb and Vittersø (2017) indicated, intrinsic motivation and positive affect both are essential in motivational processes.

Positive affect is described as the status of feelings of pleasure and immersion on challenging activities for achieving a satisfying experience (Løvoll, Røysamb, & Vittersø, 2017). Positive affect can present as happiness, interest, feeling grateful, and liking. Also, Colomeischi
and Colomeischi (2015) defined positive affect as the students' strong beliefs in their ability to reach goals while engaging in mathematical activities. Many experimental studies have shown evidence of the value of positive affect and how it can help students' success in school. Students who have high levels of positive affect demonstrate increased feelings of self-efficacy, intrinsic interest, performance, problem-solving skills, and developing new skills (King, McInerney, Ganotice, & Villarosa, 2015; Lyubomirsky, King, & Diener, 2005). For example, Pinxten, Marsh, De Fraine, van den Noortgate, and van Damme (2014) found that positive affect experience and enjoyment in mathematics is correlated with students' curiosity and interest to learn more about new math topics continuously.

Intrinsic motivation and positive affect both are essential in motivational processes (Løvoll, Røysamb, & Vittersø, 2017), as Bye, Pushkar, and Conway (2007) documented that intrinsic motivation substantially correlates with positive affect, where an increase in the level of intrinsic motivation is accompanied by an increase in the levels of positive affect when the students are active in learning. On the contrary, a decrease in the level of positive affect leads to a decrease in intrinsic motivation. In other words, Haidt (2000) showed that high levels of one's positive affect cause a strong intrinsic motivation for learning. Isen and Reeve (2005) indicated that the influence of positive affect on intrinsic motivation directly fosters and increases intrinsic motivation, and thus individuals in the positive-affect condition experience increased feelings of interest and satisfaction and improve their performance in problem-solving tasks because they are engaged in interesting activities.

In this study, intrinsic motivation theory was utilized to explain how students are motivated through using digital math games. So this study employed only one motivational factor of intrinsic motivation, namely positive affect, to measure fourth-grade students'
motivation when they use digital math games in Saudi Arabia. The intrinsic motivation theory was applied because the questionnaire used in this study only measured positive affect. Extrinsic motivation theory was not applied in this study because the questionnaire that measures extrinsic motivation is designed for eighth-grade students, not for fourth-grade students. The positive affect factor was used to address the research questions and formulate the survey items.

The first research question was: To what extent is the use of the digital math games related to elementary students' motivation to learn math? This research question focused on how the use of digital math games impacts students' motivation to learn math. Utilizing this factor allowed investigation of whether the use of IXL digital math games increased fourth-grade students' intrinsic motivation to learn math. Most importantly, this motivational factor helped to design the questionnaire items to determine the students' level of intrinsic motivation. For instance, the motivation score levels allowed to identify whether students were intrinsically motivated or not during playing the IXL math games. Also, the motivation score helped determine whether digital math games may have a role in enhancing intrinsic motivation among fourth-grade students in Saudi Arabia. Additional information about motivation theory is discussed in the following section.

Gender is another factor that might affect students' motivation when using digital math games. Ajai and Imoko (2015) indicated that males and females were not different in learning math when using math games; however, male students were lower than female students in learning math and females were superior and worked better on math activities. By contrast, Lowrie and Diezmann (2011) found that both genders differ in learning math, where boys seemed to perform better and faster than girls on number and mental rotation tasks that required using new strategies. On the other hand, girls do better in computational accuracy and math
problem-solving tasks in playing digital math games (Lowrie, & Jorgensen, 2011). The results of Fahuzan and Santosa’s (2018) study showed evidence that males’ and females’ motivation were not statistically significantly different in learning mathematics in pretest intervention. But in post-test intervention, the male students’ motivation was significantly higher than the female students’ motivation in learning math using a smartphone game. Consequently, Osunde, Bacon, and Mackinnon (2018) indicated that gender has the potential effect on students’ intrinsic motivation when playing digital math games.

The second research question was: To what extent does gender moderate the relationship between the use of digital math games and students' motivation to learn math? This question investigated the impact of gender as a moderator on students' motivation when playing digital math games. Utilizing the intrinsic motivation theory helped to measure the level of intrinsic motivation for both genders and discover if there are differences between genders in their motivation to learn math. Additional information about intrinsic motivation and factors that influence it are discussed in Chapter 2.

Research Assumptions

There are some assumptions included in this research. It is assumed that the sample was representative of the students at an elementary school in Saudi Arabia and the participants were volunteers who could withdraw from the study at any time. Also, it was assumed that the participants would answer the survey questions truthfully and in a candid manner. The survey instrument applied in this study is suitable for measuring the students' motivation. In addition, it is assumed that the data is accurate, and there will be a gender difference in students' motivation towards learning math when they are using the digital game.
Delimitations

A delimitation in this study is the sample that was limited to fourth-grade elementary school students in Saudi Arabia who take math class that integrates digital math games. The boundaries of my study, such as place (Saudi Arabia) and school type (an international school,) can be described as another delimitation. In addition, the other delimitation of my study is the period of time limited to only one semester, but a longer study might generate different results.

Definition of Terms

Educational games are games that have an educational value and can be used in educational environments to teach subjects, learn abstract concepts, and reinforce skills. Digital game-based math learning is considered part of educational games.

Motivatio: refers to students' feelings or desires towards accomplishing specific tasks during the learning process.

Gender differences are variances in attributes, attitudes, and behaviours between males and females.

Self-efficacy "is a personal belief in one’s capability to organize and execute courses of action required to attain designated types of performances" (Artino, 2012, p.76).
CHAPTER 2
LITERATURE REVIEW

The literature review below is organized around seven major themes and the theory that supports this study: intrinsic motivation theory (Ryan & Deci, 2000a). The selected theory will be explained in greater detail throughout this section. The first theme covers various types of digital/serious games and the second is about math games in education settings. The third theme is about math games and learning outcomes and involves three subsections that address conceptual, procedural and heuristic learning. The fourth theme includes studies that explore the effect of math games on students' motivation. The fifth theme is gender differences and digital game-based math learning. The sixth theme is the education system in Saudi Arabia. The last theme is the IXL digital math game used in the school.

Motivation Theories

A general worry of teachers is motivating students to be engaged in the learning process because there is a relationship between motivation and an increase in achievement (Kappers, 2009). Therefore, motivation should be studied to understand what factors contribute to motivating students to learn.

Motivation has been repeatedly used in research contexts (Keblawi, 2009). Theories that contribute to creating human motivation are the content theories and the process theories of motivation. The content theories describe what reason motivates individuals and focuses on
identifying what an individual needs and providing motivation to meet these needs, whereas the process theories describe how human motivation occurs and what kind of process can influence our motivation (Ball, 2012). Consequently, the main content theories of motivation are Maslow’s needs hierarchy, Alderfer’s ERG theory, McClelland’s needs theory, and Herzberg’s motivation hygiene theory (Pardee, 1990). The major process theories are Skinner’s reinforcement theory, Vroom's expectancy theory, Adams’s equity theory and Locke’s goal setting theory (Pardee, 1990). These theories are described in the following sections.

**Maslow’s Needs Hierarchy**

Maslow’s theory is the most known theory of motivation, founded by Abraham Maslow (1943), who explained levels of the basic people's needs and how people are motivated to move from one need to the next higher level of need when all lower needs are achieved. In his theory, Maslow categorized motivational needs from the bottom to the top in hierarchical order into five levels within a pyramid, beginning with psychological needs, safety, social, esteem, love, and self-actualization (McLeod, 2007).

**Alderfer’s ERG Theory**

Psychologist Clayton Paul Alderfer proposed this theory, which is the extension of Maslow’s theory. He classified five needs into three stages of needs: existence needs include physiological and safety, relatedness needs comprise social and external esteem, and growth needs include inner esteem and self-actualization (Ball, 2012).
McClelland’s Needs Theory

David McClelland’s work built on Maslow’s theory, who thought that the person's needs are obtained through his/her life experience over time, thus, this theory is named or called the learned needs theory (Ball, 2012). McClelland identified three types of needs to understand motivation: achievement motivation (one's feeling a need to accomplish tasks or demonstrate competence performance), power motivation (a need for authority of a person's own work or the ability to control others' behavior), and affiliation motivation (high need for belonging, love, and interaction with others; Steers, Mowday, & Shapiro, 2004).

Herzberg’s Motivation Hygiene Theory

Herzberg’s model is commonly used in the business field. This theory states that there are some factors that affect job conditions: hygiene factors (maintenance) and motivation factors (Ball, 2012). Hygiene factors are salary, working conditions, safety, supervisors, and working security; if these are inappropriate, it can cause an individual to be dissatisfied with their job; motivation factors are intended to motivate an employee in their job to ensure increased job satisfaction (Pardee, 1990).

Vroom's Expectancy Theory

Expectancy theory is based on the assumption that an individual's behavior is the result of a process of selecting a certain behavior among a variety of behaviors with an expectation of getting the desired results (Pardee, 1990). Vroom contended that individual motivation to participate in an activity occurs through three factors:

- Expectancy is a person expects that performing a lot of effort will lead to
increased success.

- Instrumentality is the person’s belief that if he/she performs well, she/he will receive a reward.
- Valence is a person that places the values on a particular result of success (Ball, 2012).

**Adams’s Equity Theory**

Adams’s (1965) equity theory suggests that people tend to achieve a fair balance between their inputs (the performance) and their outcomes that they expect to get (rewards) in comparison with the outputs of others at the workplace. In other words, people will be significantly motivated when they feel they are treated equitably and receive fair rewards for their effort (Ball, 2012).

**Locke’s Goal Setting Theory**

Locke's philosophy of goal setting states there is a strong relationship between goals and performance when individuals have specific challenging goals and are committed to meeting their goals. In this theory, the established goals drive the individual’s behavior toward achieving the goals and tasks, particularly when the goals are difficult because hard goals require more effort from the individuals and thus lead to a higher level of the desire to accomplish tasks or goals to be satisfied (Locke & Latham, 1994).

**Reinforcement Theory**

Reinforcement theory is the process of shaping an individual's behavior through observing the consequences of the behavior (Gordan & Krishanan, 2014). Skinner’s work
emphasized the assumption that an individual behavior develops as a result of the kind of consequences they are exposed to or by using reinforcement, punishment, and extinction.

Intrinsic and Extrinsic Motivation Theories

Motivation in education emphasizes the learner's motivation to learn. Motivation has a lot of different definitions depending on the fields of study, but from an educational perspective, the term “motivation” means an internal driving force that directs individuals' behavior to learn and do specific activities. Csikszentmihalyi (as cited by Yarar, 2015) proposed intrinsic motivation, where a person is intrinsically motivated toward performing a task or for skills improvement and is fully immersed in “what he or she is doing” (p. 33). In 2009, Hong, Cheng, Hwang, Lee, and Chang defined motivation as behavior or actions that cause people to act toward their desires, needs, and goals, such as having a desire to learn new knowledge and skills. From Kitching and Wheeler's (2013) point of view, the term “motivation” can be defined as “the amount of attention and effort that an individual put into different activities” (p. 113). In other words, motivation is a combination of an interaction between an individual and a situation to achieve certain goals in the presence of essential motivational factors (Hong, Cheng, Hwang, Lee, & Chang, 2009). This motivation is called self-reinforcing (Eggan & Kauchak, 2007) or could be defined in terms of self-motivated learning (Weibell, 2011).

A motivated learner automatically is enthusiastic and engaged to demonstrate competence, interest, and efforts in what they are performing toward attainment of their goals (Habgood & Ainsworth, 2011). Thus, motivation plays an important role in changing an individual’s behavior toward performing tasks (Beres, 2011). Most importantly, a person might be motivated by any external reward or by his/her own interest to master the task (Palmer, 2005).
The motivation is often categorized by two major types: intrinsic and extrinsic motivations. These two motivations can impact individuals’ behavior (Ryan & Deci, 2000a). According to intrinsic motivation theory, this intrinsic desire of individuals creates feelings of enjoyment because they realize the value of what they are doing and succeed in achieving a challenging task (Usher & Kober, 2012). This inferred, intrinsic motivation is most effective to enhance students' learning and achievements. The intrinsic motivation is affected by many of motivational factors such as students’ self-confidence (learners' belief that they have an ability of doing that task), competency (learners' feeling of being efficient and having the knowledge when interacting within the environment), positive affect (learners' feeling of enjoyment and enthusiasm on doing new or challenging tasks), task values (learners' desire to achieve the task because it is worth completing the task), autonomy/control (learners' feeling that they have control of their choices of goals and/or their learning strategies are appropriate for undertaking the tasks), and relatedness (learners' sense of belonging to a classroom). These are major motivational factors that stimulate intrinsic motivation for learners to be intrinsically motivated to learn (Tuan, Chin, & Shieh, 2005; Usher & Kober, 2012). Lopez-Morteo and Lopez (2007) conducted an empirical study that showed the use of math games is a great way for intrinsically motivating students when doing tasks by providing them with control and self-efficiency in choosing the suitable strategies to achieve activities' goals. Additionally, Cordova and Lepper (1996) compared the intrinsic motivation of two groups of elementary students who used the mathematics game to students who learned in a traditional environment; they noticed that games significantly enhanced higher levels of intrinsic motivation in the game-based environment.

On the other hand, Clinkenbeard (2012) clarified the term of “extrinsic motivation” as learners' desire to achieve an activity, but focusing on receiving support from external factors
such as rewards, grades, and prizes. So learners do not feel very motivated by themselves but are
pushed to perform tasks for the extrinsic goals (Ryan & Deci, 2000a). As Gambari, et al. (2016)
stated, extrinsic motivation can be used as a motivational strategy, so often students are
extrinsically motivated to accomplish tasks for getting the reward. All these motivations are
factors to push learners to learn effectively. Identifying and measuring students' motivation is
challenging because most of us are motivated through a combination of intrinsic and extrinsic
factors. Thus, Ryan and Deci’s (2000a) motivation theories will help me determine if math
games could be the right tool to motivate students to learn math.

Digital/Serious Games

Recently, playing digital games has become more common among young people. The
popularity of digital games is leading to increase attention from educators for use in education
because of a variety of positive outcomes (Cheng & Su, 2012). Before discussing the previous
research on games, it is important to discuss the various forms of games, like simulations games,
computer games, serious games, and digital games-based learning, that we often see in the
literature. So this section of the review will present a range of empirical articles relating to
different types of education games with their learning outcomes.

While there is a lack of literature on understanding the effects of games and how best to
use games in learning, there are studies highlighting the positive side of playing games. As
Becker and Jacobsen (2005) reported, most of the teachers who used simulations games in class
found games were beneficial for making learning more fun and interactive. In 2009, Sardone and
Devlin-Scherer examined teacher candidate perspectives toward integrating digital gaming into
contemporary curricula to support students’ development of complex reasoning techniques. The
study used mixed methods of a survey, interview, and observations instruments to gather teacher candidates' responses to digital games. The findings indicated that participants felt that students learned more while playing games, which allowed them to understand difficult concepts and have more engagement in the subject, which leads to improved student abilities to reason critically, better concentration levels, and more developed problem-solving skills.

A subsequent quasi-experimental study by Yien, Hung, Hwang, and Lin (2011) was conducted with third graders from an elementary school to discover the influence of a game-based learning model on the learning outcomes and students' learning attitudes toward a nutrition course. The experimental group was taught nutrition education with computer game-based learning while the control group was taught the nutrition course with a multimedia PowerPoint. The findings of the survey were positive and revealed that computer game-based learning promotes the learning outcomes and perceptions of students. In addition, it was found that the games were the best way to stimulate students’ learning motivation, increase students’ interest in studying health courses, and develop abstract thinking. This study showed that the game-based learning model was useful for all participants regardless of gender with respect to nutritional knowledge and learning attitudes.

The primary interest of Connolly, Boyle, MacArthur, Hainey, and Boyle (2012) was to explore the literature about the positive effects of playing computer games and serious games on users above age 14 in learning, skill enhancement, and engagement. The findings reported that playing computer games has a higher impact on affective, motivational, support knowledge acquisition, and content understanding outcomes than perceptual, cognitive skills, behavioral, and social/soft skills outcomes.
Also, Hess and Gunter (2013) in their study found the lack of research on the effectiveness of video games led to the need for further investigation on using serious games in online formats. A sample of 92 students were selected for this research to compare student learning experiences, outcomes in the amount of time that students take to complete courses, and the students' interaction, motivation, and performance between a serious game-based and a non-game-based online American History course. The results from this mixed-methods study indicated that students had ease of understanding and were intrinsically motivated through their positive social interactions and through the support of their innate psychological needs in game-based format. Additionally, students using the serious game-based online format in the American History course reported higher performance as compared to those in the non-game-based course.

Because there was lack of consensus in prior research on video games as an effective instructional means for engaging learners in foreign language learning, Yuan Lee (2008) examined the effect of game genres on the use of foreign language learning strategies among 162 undergraduate freshmen from an institute of technology in Taiwan. These strategies were categorised as direct (memory, cognitive, and compensation strategies) and indirect (metacognitive, affective, and social strategies). These strategies were implemented to the four learning skills of listening, reading, speaking, and writing. During the study, different types of games were used such as simulation games, role-playing games, sports games, action/adventure games, and virtual pet games. This quantitative design with survey demonstrated positive results that game genres have an impact on the choice of different language learning strategies, as the students stated that using simulation games and role-play were more preferable than virtual-pet games for helping learners master a second/foreign language. Yuan Lee found the simulation and role-play games had an influence on the students' cognitive and metacognitive learning strategies.
and students were able to discover the meaning of the unknown words. Simulation games also encouraged students to continue playing when confronting a language barrier.

The results of the aforementioned studies conducted in the area of educational games reveal that researchers contended that most of these types of games meet their potential to be a valuable tool for engaging learners in learning different languages because they created fun and enjoyable environments (Lee, 2008). Further, findings indicated that integrating the game-based learning approach into learning activities in nutrition courses increased students’ motivation and improved the students’ nutrition knowledge (Yien et al., 2011). In addition, similar results have been reported that video games consist of a range of advantages, as Hess and Gunter's (2013) research confirmed that students who used a serious game had higher understanding, motivation, social interactions with peers, and performance as compared to those not using games. These findings linked to Connolly et al.'s (2012) and Sardone and Devlin-Scherer's (2009) studies that showed playing computer games and serious games supported cognitive, behavioral, and social skills and knowledge acquisition.

Math Games

The following section includes some studies that have been conducted on the use of digital math games to teach students mathematics.

In 2002, Ota and DuPaul conducted a qualitative case study with a sample of three male children who had attention-deficit hyperactivity disorder (ADHD) from a private school because there were only two studies that paid attention to the effects of using computer-assisted interventions (CAI) on that student category. Also, one study did not examine the effect of CAI on academic performance. Thus, the purpose of Ota and DuPaul's study was to investigate the
effects of using CAI with a game format to improve math performance and attention. Also, CAI would raise the attention span of the three children. The authors did observations during their study to collect data. The results showed that all three participants with ADHD's math performance, attention behavior, and motivation significantly improved when they used CAI software. Additionally, the students' academic engagement increased highly when playing a game.

An empirical study by Ke and Grabowski (2007) incorporated computer games within cooperative learning techniques in mathematics to discover whether this combination could be beneficial to improve K-12 mathematics education. Thus, this experimental design study intended to examine the effects of cooperative game playing through the Teams-Games-Tournament (TGT) on fifth-grade students’ math performance and attitudes between the interpersonal competitive game playing and non-game playing conditions. The findings showed that the TGT math game was effective for promoting both test-based cognitive learning achievement and affective learning outcomes and had a positive significant effect on math performance and attitudes. The students' math performance in cooperative and competitive game-playing groups was higher than the control groups.

Ke (2008) carried out a case study on 15 fourth- and fifth-grade students who were enrolled in the summer school math program using ASTRA EAGLE educational computer math games. These games are composed of eight different mathematical games that target math skills such as solving simple equations, measurement problems, comparing whole numbers, and mapping x and y coordinates. This program was developed to reinforce students' math skills and attitudes toward math learning. This study demonstrated that playing ASTRA EAGLE increased the positive attitude of students regarding learning mathematics and supported social
communication and collaboration among players, who were very active in communicating with peers and interacting with the games. Furthermore, the researcher found that during game playing sessions, the students were engaged in cognitive thinking and showed progress in solving mathematical problem questions as well as expressing feelings of enjoyment.

In 2009, Huang and Ke designed math games for their quasi-experimental research to explore the effect of integrating computer games into the mathematics instruction on elementary students' motivation of learning mathematics, mathematics achievement, and pupil-teacher interactions in the classroom. Two classes used game-integrated instruction and the other class used traditional math instruction. The study discovered that the difference between two groups, experimental and control, in their motivation and achievement scores were statistically significant. The results showed that after the instruction the experimental-group students who used math games integrated into math classroom activities had a significant improvement in motivation, achievement, and a more positive attitude toward learning mathematics compared to a traditional learning environment. Also, it proved the ability of games to motivate students to learn mathematics.

Chen, Lin, Looi, Shao and Chan (2012) did an experimental study using the Cross Number Puzzle math game in an elementary class to help students practice and develop arithmetic skills. This game is designed to promote the concept of addition and subtraction in students through playing the game in three different ways: collaboratively, individually, and traditionally without games. The data revealed that in general students with low math ability progressed more in arithmetic skills and their confidence increased while playing the game. In comparison among the students' results in the three classes, students who played the game were
highly motivated and had better performance than the control group who did not play the game, whereas students in the collaborative class achieved better performance than the individual class.

Another educational mathematical video game named NumberShire was designed to facilitate K-2 students' knowledge (Nelson-Walker et al., 2013). The students were at risk for mathematics difficulties (MD) regarding whole number concepts in three scopes, which are counting and cardinality, number and operations in base ten, and operations and algebraic thinking. Results from the interviews with the students, the observations, and the teacher interviews showed that students who played the NumberShire game had significant improvement in mathematics learning and were more engaged in and excited about math activities, which led to improved math skills and better increases in students' performance in mathematics. They became more fluent in solving math problems.

The study by Chang, Evans, Kim, Norton, and Samur (2015) explored the effects of using the Math App game to improve mathematics proficiency and performance for middle school students (Grades 6-8) with low math performance. The researchers found the Math App game revealed positive evidence that students across all three grades who had low math performance learned fraction concepts during game playing. Additionally, students’ mathematical proficiency levels and performance became higher than those who used pencil and paper for math and did not show any improvement in math performance.

As shown above, math is an interesting subject that has been discussed among researchers for many years. Researchers (e.g., Nelson-Walker et al., 2013) found that math learning must be reformed; thus, they proposed computer games as a solution to foster mathematics learning and facilitate students' knowledge. Conclusively, previous research has shown that a variety of math games have been used in classrooms to promote complex math
concepts – fractions, addition, and subtraction – as well as serve as a great motivational tool, as Chen et al. (2012) and Huang and Chong (2009) found. Other educational researchers (Ke, 2008; Ke & Grabowski, 2007; Nelson-Walker et al., 2013) believed that math games can be supportive tools for improving some mathematical skills such as cognitive thinking, basic arithmetic, and problem solving in all primary-grade students to become mathematical-thinking solvers.

Planning to teach mathematics through playing games was found to be a useful method for students with low math performance (Chang et al., 2015) and learners with attention deficit/hyperactivity disorder (ADHD) because they encourage communication and collaboration among students that helped their ability to solve arithmetic questions (Ke, 2008). Therefore, students' math performance substantially progressed faster as well as their feeling a sense of confidence and positive attitudes toward math learning (Ota & DuPaul, 2002).

Schoenfeld (1985), expressed understanding mathematic curricula based on the students' ability to solve mathematical problems. As a result, he identified knowledge in four categories are required to solve problems in mathematics: (1) Resources refers to the individual’s knowledge of mathematics or mathematical experiences, which breaks down math skills into conceptual knowledge and procedural knowledge. It is emphasizing students' engagement in and practices with mathematical problem solving. (2) Heuristics is the sequence of strategies and techniques the students use for problem solving. (3) Control means students’ decision making that is related to the aspect of metacognition (self-regulation and monitoring. (4) Beliefs system is the individual's view on mathematical behavior and performance (Schoenfeld, 2016). All four factors impact students' ability to think mathematically for mathematical problem solving and they are important elements that must be considered when students become mathematical problem solvers (Mills, 2015). Based on these results, Pape (2004) illustrated that the
Mathematical problem-solving process is composed of three kinds of knowledge structures: conceptual, procedural, and heuristic knowledge.

Math Games and Learning Outcomes

Math Games and Conceptual Learning

Within the past five years, digital games-based learning has been formally integrated into schools to improve the learning environment (Gros, 2007). Many teachers were willing to use these games in mathematical activities to stimulate students to be actively engaged in mathematics learning because students who lack knowledge of mathematics concepts see this subject as very difficult (Gros, 2007).

This issue of mathematics understanding among students is a source of concern for teachers in Indonesia and other countries (Veloo, Md-Ali, & Chairany, 2016). Many of them are trying to use math games to teach mathematical concepts. However, the question is whether using games will actually be effective for teaching complex mathematical concepts. In response to this question, Veloo, Md-Ali, and Chairany (2016) discussed the effect of implementing a cooperative Teams-Games-Tournament (TGT) on the understanding of and communication in mathematics for secondary students in Indonesia. This quantitative approach, with an open-ended mathematics test for pre- and post-tests was employed in two different groups, control and experimental, to measure the students’ mathematics understanding and communication. Test results indicated the cooperative TGT game was helpful towards students' mathematics understanding and communication, where this method showed there were significant differences in mathematics understanding and communication between cooperative TGT and conventional
groups. For the experimental group, the interaction between groups who used TGT led to increased scores in mathematics communication. Also, mathematics understanding was higher than the control groups.

Other research by Pareto (2014) focused on designing a learning environment that targeted primary-grade students from Grades 2, 4, and 6 to support basic mathematics conceptual understanding of integers, arithmetic operations, and reasoning through using teachable agents games, which are computer programs. In this environment, students learn by playing the game and teaching their agent to play. The study consisted of two parts. The first was designed as a quasi-experimental study. The second was used at the study’s end to examine students’ perceptions and performances in-game and out-of-game (mathematics performance). The study’s findings showed that this learning environment contributed to engaging primary students in advanced mathematical thinking. There was a significant difference between the two groups in a fundamental conceptual understanding of mathematics where low-achieving students in the game-playing group gained greater learning for all four math problem types (computational, conceptual, effective strategies, and other problems) than the control group. Also, the students’ performances improved and progressed as they answered their agents’ questions while playing games.

In the same manner, Pareto et al. (2012) conducted their study on two math classes of third-grade students. The researchers noticed that, in general, most educational games had an impact on learning and motivation, but not many games had effects on skills and competency acquisition, conceptual understanding, and attitudes toward a subject. To address this problem, the authors designed their own teachable agent (TA) math game. This game was used to investigate how the game affects students' conceptual understanding of basic arithmetic and
encourages positive attitudes towards mathematics. Also, they discussed how collaborative and competitive activities affect understanding and motivation when students played the game. A quantitative data method was used. Both groups were given pre-test questionnaires two weeks prior to starting to play the game during class sessions to test students' conceptual understanding of math and attitudes toward mathematics. Then, after the game playing sessions concluded, a post-study questionnaire was administered, and then semi-structured interviews and observations were conducted to concentrate on collaborative and competitive behaviors during the game-play meeting. The researchers found that playing the game had a positive effect on students’ conceptual understanding of basic arithmetic and on students’ performance. Students' performance progressed and increased on average 3.6 points for the game-playing group as compared to the control group. In addition, the math game was a powerful motivational factor in helping students engage in collaboration and competition with math.

In conclusion, the results of previous research have conveyed that integrating math instructional activities or tasks via digital games-based learning helps students simply absorb the lessons. Pareto et al. (2012) and Pareto (2014) conducted similar studies on middle-school students, and in both studies, the results were the same. The participants surveyed at the end of the game playing sessions had an increase in motivation, performance, and improvement in arithmetic skills. Also, students were better able to understand basic arithmetic concepts compared to students who learned from the traditional method of teaching. Based on that, the findings showed that utilizing games to teach math improved students' abilities to understand math concepts, theories, and equations that were taught during lessons and mathematical problem-solving skills that were instilled in the learners’ minds. This evidence is aligned with the
study of Veloo, Md-Ali, and Chairany (2016) that showed that students who used games had better understanding of mathematics than those who did not use them.

**Math Games and Procedural Learning**

Before conducting their own study, Chang, Wu, Weng, and Sung (2012) reviewed several studies that used problem-posing activities to improve students' performance in math and help students energetically engage in mathematical learning. Unfortunately, Chang et al. (2012) found the problem-posing system activity alone had defects because students did not engage or had low achievement in difficult mathematical tasks. Since students found these so difficult, they were not motivated to perform the activity. This problem helped the authors discover that their proposed games must be incorporated into the original problem-posing activities that other researchers worked with. In their game, they added four problem-posing phases: posing the problem, planning, solving the problem, and looking back into a problem-posing system for mathematics learning to study its effect on students’ problem-posing ability, problem-solving ability, and capacity to have a flow experience while playing the game. The flow theory was used in this game-based learning context. Ninety-two students from an elementary school (Grades 4 and 5) were recruited for the study and a quasi-experimental design within a quantitative approach was used to discover changes in students’ problem-posing ability, problem-solving ability, and flow experience both before and after the game treatments. This study revealed that the problem-posing system helped students better understand mathematics concepts. The students in the experimental group who struggled with problem-solving showed improvement in this skill. In addition, students were in a higher state of intrinsic motivation while working on math problems than before they played the game.
Similarly, a study conducted with a sample of two classes at an elementary school by Hwang, Wu, and Chen (2012) explored the effectiveness of applying web-based problem-solving activities in an online game to improve students’ learning achievements, students’ flow experiences, and students’ attitudes toward science learning. Hwang et al. used a quantitative method with interviews and a questionnaire for measuring the students' learning attitudes, flow experiences, and achievements. Consequently, this study showed that students in the online game approach had a significantly higher learning interest than those who learned with the traditional web-based learning approach. Also, the online game enhanced the students’ intrinsic motivation. Thus, with this high motivation, students felt confident and achieved better performance, were highly engaged during the web-based problem-solving activity task, and approached solving problems with full involvement. Students' attitudes toward science courses also improved, and they focused better because they were enjoying playing the game.

Maloy, Edwards, and Anderson (2010) created 4MALITY computer game, a web-based mathematics tutoring system that involved set of strategies for teaching fourth-grade students math problem-solving skills and creative writing when solving math problems. In their study, they provided these games to discover whether the use of a web-based tutoring system would support and improve students' motivation, problem-solving, and test-taking strategies. Based on this experimental study, the results demonstrated that students' motivation, problem-solving skills, and performance increased from pre-test to post-test and they became better problem solvers. Moreover, they were successfully able to write and solve math problems such as fractions and number operations math concepts.

Mathematics instruction activities entirely depend on solving arithmetic problems and critical thinking. According to the results that emerged from the multitude of empirical studies,
most researchers agree on the positive impact of integrating problem-solving activities into math games on students' academic achievement. For instance, Hwang et al. (2012), Chang et al. (2012), and Maloy, Edwards, and Anderson (2010) reported that when they blended games and math instruction problem-solving activities, they found that students began dealing with math problems as creative problem solvers and mathematical thinkers through practice. During these activities, they were fully engaged with solving the arithmetic problems. As a result, the researchers confirmed that math games are a positive addition to a lesson plan.

Math Games and Heuristics Learning

Kraus (1982) has examined two exploratory studies on students' use of problem-solving heuristics processes and the cognitive effects of math-related games on mathematics learning. Study 1 included doctoral students in mathematics who had experience in solving mathematical problems, whereas eighth-grade students who were novices and not experienced in solving mathematical problems were selected for Study 2. In both studies, the students played a variation of Nim. While the students were playing, the researcher noted that Group 2 used more heuristic strategies than Group 1. The findings of these two studies showed that heuristics play a significant role in helping students solve math problems. However, the experienced students in Study 1 saw the game as not problematic and simple and they were able to fully solve the math problems, but the novice students in Study 2 viewed the game as difficult and extensively relied on the use of heuristics.
Math Games and Students' Motivation

Digital games-based math learning would likely be used more heavily if empirical studies showed solid results about the effect of games in increasing students' motivation to learn and improving students' academic achievement in mathematics. To achieve this effort, Kappers (2009) implemented an experimental study to examine the effects of an educational video game on mathematics achievement and motivational differences between sexes in seventh-grade algebra in-class activities. Within this mixed-method design, the researcher applied observations and interviews with students and math teachers as well as district benchmark exams to measure mathematics academic achievement. Also, the researcher used Keller’s ARCS motivation survey to measure mathematics class motivation. Data revealed there was a score increase in academic mathematics achievement, but there was no statistically significant increase in mathematics class motivation for males and females after using an educational video game.

Kebritchi, Hirumi, and Bai (2010) conducted an experimental-design study when they found that there was little empirical research about the effectiveness of games on learning in school-context settings and found contradicting findings in previous research due to methodological flaws in those studies. Based on that, the researchers used a mixed quantitative and qualitative method to investigate the effects of a 3-dimensional (3D) modern mathematics game (DimensionM) on high-school students' mathematics achievement and motivation. They also studied the role of prior mathematics knowledge, computer skill, and English language skill on the students' achievement and motivation when they played the game. The data were collected through using Keller's ARCS model (1987) motivation surveys to measure students' motivation. The findings showed that there was significant improvement in math achievement in the
experimental group, but there was not improvement in motivation in either the control or experimental group. However, students who played the games in their classrooms and school labs had greater motivation than students who played the games only in the school labs. Also, prior knowledge, computer skills, and English language skills did not show a positive effect on students' achievement and motivation for the experimental group.

Habgood and Shaaron (2011) carried out a mixed-method study using the Zombie Division math game for teaching elementary students to evaluate the relationship between the math game and intrinsic motivation and extrinsic motivation. The 58 students in the study took a pre-test and a post-test and participated in an interview. The findings revealed that the mean of students' intrinsic and extrinsic motivation scores for both groups (experimental and control) significantly increased from pre-test to post-test. Also, there were no significant differences in motivation between boys and girls.

In 2013, researchers Plass, Homer, Perlin, O'Keefe, Hayward, and Stein studied how using an educational mathematics video game that involved three modes of playing (individual, competitive, and collaborative) would affect the learning, performance, and motivation for randomly assigned middle-school students. The researchers applied the educational context of learning, achievement goal theory, and interest theory to support the three modes of play and used these as a guide when they designed the FactorReactor game. The researchers used a quantitative approach within experimental methods to collect data from 58 middle-school students surveyed within each mode of play: individual, competitive, and collaborative. The results showed that the game was beneficial for math comprehension, which led to an increase in students' motivation, performance, and competition for learning math, and arithmetic skill. Also, the FactorReactor game positively impacted students’ learning because they focused more on
learning the subject to develop arithmetical skill and increased their enjoyment while playing the game.

Jones (2015) employed a quasi-experimental research design to investigate the effects of games and competition on student motivation in the mathematics classroom. The researchers used pre- and post-test surveys to collect data from 376 elementary-, middle-, and high-school students in a rural school. The overall results showed a statistically significant increase in students' motivation and competition from the pre- to post-test when playing games in the mathematics classroom. By comparing the results of pre- and post-tests, the results of the post-test indicated a sharp increase in the mean of motivation scores compared to the pre-test. This result suggests the students enjoyed playing math games and games also improved their motivation.

In 2015, Nguyen’s study on university students in Vietnam examined the impact of a web-based simulation game on students’ intrinsic motivation for those who used games, compared to those who did not use games. He found that students showed higher levels of intrinsic motivation and experienced a deeper level of learning when they learned through the game-based learning environment than other students who learned in a traditional school setting. Also, the results showed that 51.7% of students agreed that games were enjoyable and produced competence and interest.

A qualitative case study was conducted by Barreto, Vasconcelos, and Orey (2017) with six elementary-school students to explore the students' motivation and engagement through playing Club Penguin math video games. Data collecting involved interviews, observations, and video recordings of the screen during the game playing. The findings showed the math video
games increased the students' engagement and intrinsic motivation. The students' motivation to learn math through playing math games was both intrinsic and extrinsic in that study.

Meister (2018) carried out a mixed-methods approach to investigate the impact of digital game-based learning (DGBL) on seventh-grade students' motivation and experience in mathematics. In this experimental study, students in the treatment group were introduced to DGBL while the control-group students received instruction through a traditional non-gaming math lecture. The results of this study revealed that the DGBL intervention influenced the students’ procedural and conceptual knowledge and experience and enhanced motivation (interest and enjoyment). The two groups differed significantly in gaming experience, where the students in the treatment group reported positive experiences and looked forward to learning math using the DGBL. Also, the findings showed that there was a slight increase in the experimental group's interest, task involvement, and enjoyment scores compared to the students in the control group.

Similarly, another experimental study (Manginas & Nikolantonakis, 2018) aimed to evaluate the effect of incorporating online digital math games on students' intrinsic motivation as well as understanding of basic mathematical concepts. The participants included four students with mild intellectual disabilities divided into two groups, with the experimental and control group, each containing two students. The results revealed that there was a significant difference between the two groups: the students in the experimental group had higher levels of intrinsic motivation including increased pleasure, interest, effort, and perceived competence. This group also had high self-confidence and performance in mathematics in comparison to the students in the control group. Overall, this experiment suggested that using digital games to teach
mathematics had a positive effect for enhancing intrinsic motivation, confidence, and learning experiences in students with mild intellectual disabilities.

Previous Studies Summary

In conclusion, in recent decades, many students have suffered from a lack of motivation to learn math and many of them have negative attitudes toward math (Nelson-Walker et al., 2013). The reason for this might be because the teaching methods used have contributed to shaping a lack of desire regarding learning math (Almaleki, 2010; Veloo, Md-Ali, & Chairany, 2016). The solution is that educators must find alternative ways to motivate students and change their attitudes about math by learning mathematics-based games and using them as a motivational tool (Kebritchi, Hirumi, & Bai, 2010). Motivation drives students' behaviors for learning and plays a prerequisite role in the construction of students' knowledge, performance tasks, and academic success. Consequently, teachers must to be aware of and consider motivating students, which is a major factor for students performing at a higher level academically. The motivation theory argues that motivation to learn is influenced by extrinsic and intrinsic motivation factors; some of the internal aspects include the student’s self-competency, confidence, self-reinforcement, and anxiety, and external influences include rewards and grades (Egga & Kauchak, 2007; Nguyen, 2015). All of these important aspects contribute to shaping a student's personal motivation.

It is evident that the motivation theories as discussed in the literature review support and are consistent with the findings in Plass et al.'s study (2013), which revealed the effectiveness of using digital games for increasing students' motivation to keep them engaged in the lesson and increase mathematics achievement in classroom settings. Furthermore, numerous studies have
provided evidence that games-based math learning appears to be a powerful tool in teaching mathematics and is one of the factors that contribute to making math a fun subject, if this strategy is implemented properly (Connolly et al., 2012). These findings correlated with Nguyen’s study (2015), which revealed that university students who used game-based simulation were able to learn math activities more efficiently, as they had a greater level of flow, motivation, and interest than those who did not use the game. Additionally, students’ mathematical problem-solving ability skills were fostered, and they understood mathematics concepts when they admirably solved math problems. This caused their mathematics performance to rise while playing the games (Chang et al., 2015). In this way, it allowed the students to incorporate their experiences, solve problems, increase self-efficiency, and achieve required learning objectives in a short amount of time (Maloy, Edwards, & Anderson, 2010).

However, two experimental research studies have confirmed that digital games are not always effective or the perfect learning tool. As Kebritchi, Hirumi, and Bai (2010) found, modern 3D mathematics games improved students' math achievement but did not contribute to increasing students' motivation in either the control or experimental group. Kappers (2009) referred to a game’s failure in promoting students' motivation for both males and females when using an educational video game in mathematics class while arguing that the game had strengthened math performance across all grades.

Gender Differences and Digital Game-Based Math Learning

Tsai (2017) found that the majority of past studies conducted on gender differences among males and females were for the single-player game mode in game-based learning environments and few studies on gender differences in multiplayer game modes. In
addition, he found some researchers indicated that no gender differences exist in learning results in game-based learning environments. To further confirm the validity of these results, Tsai integrated the TRIS-Q game, which consisted of tic-tac-toe with multiple-choice questions about energy education to discover the gender differences among students' learning performances, perceptions, and gaming behaviors in two game modes: single-player game and multiplayer game in a game-based learning environment. In the experimental study, the data were collected through 74 students from Grade 9 of a high school in Taiwan who were taking the pre-test and the post-test that focused on energy knowledge as well as the survey about their gaming behavior, competitive attitudes, and perceptions regarding the game activities. The findings generated found there was a significant difference between the males and females in online gaming experiences. Both genders showed positive game participation behaviors, perceptions, and attitudes toward the quizzes. Males preferred the multiplayer game mode, but most females preferred the single-player game mode. Before the experiment, the males' gaming attitude was more positive than the females', although the females' learning performance on energy knowledge acquisition was better than the males after playing the game.

Kim and Chang (2010) examined the effects of using math computer games on the math achievement of fourth-grade students. According to their findings, math achievement between male and female students was different; the achievement scores of females were lower than their male classmates. In addition, male students' performance was higher than females when both played math games. One year later Joiner et al. (2011) reported significant differences between males and females in the amount of time spent and the type of preferred video game among all age groups in different countries; females were less likely to prefer playing digital games than males. They supported this conclusion: 99% of boys play video games and 94% of girls.
In the same manner, Lowrie and Jorgensen (2011) focused on examining whether there were differences among boy and girl elementary students in the amount of time spent playing games and their preference, specifically the type of mathematics sense making promoted in the games students play. They recruited 426 students from Grades 6 and 6, aged 10–12 years, from two states in Australia to participate in the questionnaire. This questionnaire related to students' behavior in use of entertainment-based digital games, their preference for types of games, time spent playing, and the content of games, specifically mathematics content. This quantitative study revealed there were statistically significant gender differences between boys and girls in choosing the types of mathematics games that they preferred to play. Girls favored playing games that required problem solving, quantitative computations, and the interpretation of graphs; however, boys liked games that related to visual/spatial engagement. Also, results revealed that boys spent a longer time playing digital games than girls.

In contrast, Barab et al. (2007) employed the Quest Atlantis (QA) game, allowing students to interact in real-world experiences to support social commitment and action through online academic activities such as conducting environmental field studies, writing a story about travelling through various virtual biospheres, and reflecting what they learned from lessons. The researchers found no significant difference in gender regarding students' learning engagement in academic activities, but girls were slightly higher in engaging longer in online chat, writing reflections, and participating in quests in their online notebooks than boys.

Later, in 2009, similar results were generated when Kappers conducted a mixed-method analysis through observation, interview, and survey to investigate sex differences of seventh-grade students in mathematics achievement and motivation when a math educational video game was used to teach algebra in mathematics classrooms. He used district (countywide) benchmark
exams to measure mathematics achievement and Keller's ARCS motivation survey measuring motivation to collect data. The analyses findings revealed that academic mathematics achievement and motivation between both males and females were found to have no statistical difference after using the math game.

The results of Fahuzan and Santosa's (2018) study showed evidence that males’ and females' motivation were not significantly different in the pre-test intervention. But in the post-test intervention, the male students’ motivation was significantly higher than the female students’ motivation in learning math using a smartphone game.

The aforementioned studies present an overall picture that learners' performances are different by gender and that they have different attitudes towards digital game-based math learning. Some studies (Kim & Chang, 2010; Tsai, 2017) have shown the positive effects of games on gender behaviors, perceptions, and attitudes toward the usability of digital games. Gender differences affect how they engage in online gaming, choose the types of mathematics game, and learning style they prefer. More specifically, the findings of past studies demonstrate that females usually outperformed males in engagement in academic activities, while males in online gaming favored visual/spatial engagement much more than the females (Barab et al., 2007; Lowrie & Jorgensen, 2011). In addition, males and females differed in learning motivation and performance, as previous research has suggested (Barab et al., 2007; Chung & Chang, 2017; Kappers, 2009; Tsai, 2017).

Education System in Saudi Arabia

Before the unification of the Kingdom of Saudi Arabia, there was not any structured educational system. Education was delivered in mosques, and it was limited to reading the holy
book of the Koran, writing religious texts in Arabic, and learning calculation. The beginning of education was in 1932 when Saudi Arabia formally announced its status as a nation (AlMunajjed, 1997). A few Islamic schools had been established in certain places and the main subject was religious studies, but the content of education remained the same as it was before. In the 1930s the first official education system was implemented in Saudi Arabia, and in 1945 a royal decree was issued by King Abdulaziz Al-Saoud to build schools around the kingdom. By 1951, the number of public schools reached to 226 and they were intended for only male students (Bokhari, 2016). In 1954, Prince Fahd Ben Abdul-Aziz became the first founder of the Ministry of Education in Saudi Arabia (Mirza, 2008). In 1964, the primary public schools for female students were established (Bokhari, 2016). To keep pace with current developments in technology, in 1995 the education sector in Saudi Arabia witnessed a big shift, restructuring its education system and introducing some changes. These changes involved the development of curricula, professional development for teachers, and improvement of the educational environment. Schools and universities in Saudi Arabia have begun to adopt e-learning in most fields, which allows students to use computers and technological tools as supplementary educational tools (Salama, 2015).

Today, in general, the education system in Saudi Arabia has two forms: public and private. It includes 25 public universities, 27 private universities, vocational schools, international schools, and more than 33,500 K-12 schools (Royal Embassy of Saudi Arabia, 2014). The total duration of K-12 education in Saudi Arabia is 12 years; it is divided into six years for elementary, three years for middle, and three years for high school. The government provides a free education in public schools from the primary level through college level, which is available to everyone whether female or male. They are not co-educational. Furthermore, the
government provides free textbooks for K-12 students and pays monthly stipends for university students to help them pursue their education (Salama, 2015).

Most importantly, Saudi Arabia has integrated the Islamic principles, which assert that education is mandatory for all Muslims regardless of being male or female (Alsalloom, 1995) and encourages both genders to pursue education so they can be knowledgeable and become active citizens (AlMunajjed, 1997). Also, the education system in Saudi Arabia is based on the gender separation between males and females in the schools from elementary through high school (Alsalloum, 1995). Although girls and boys study separately in different buildings, they have the same curriculum for math, history, and science, except high schools. In the Saudi Arabian education system, gender discrimination happens only in high school curricula. For example, the school curriculum for boys in high schools focuses on computer sciences, professional crafts, and vocational and technical training to prepare them for future professional careers. However, subjects for girls in high schools are concentrated on teaching some skills, such as sewing, home decorating, drawing, and cooking. Thus, the main goal of educating female students is to prepare them for domestic responsibilities related to being a good mother and good wife; other subjects prepare them for pursuing careers in teaching or nursing (Al Munajjed, 1997; Bokhari, 2016). Moreover, schools for girls have their own administrations and are managed by only women; men are not allowed to enter to the girls' schools. In addition, female teachers only teach female students, while male students are taught by male instructors. Female instructors cannot teach male students and vice versa, male teachers cannot teach female students.
The IXL Digital Math Game Used in the School

The website used to provide maths games that support math learning is called the IXL. IXL is an online math website designed for K-12 curricula for practicing math skills. IXL offers personalized learning and unlimited questions with practice on different math topics that help students master math skills that they have learned during the lessons (IXL Official Blog, 2020). It is considered a supportive activity to help students understand math concepts. The math skills that are covered in the IXL game for fourth-grade students have many activities that deal with numbers, place value, addition, subtraction, multiplication, geometric measurement, decimals, and algebra, etc. For example, in an addition lesson, student may answer questions such as complete word problems that require addition, fill in the missing digits in equations, and/or complete addition patterns using increasing place values. The IXL game can be used at home, school, and in distance learning environments. There are some unique instructional features that make the use of the IXL game effective in classrooms, such as coaching, exploring, scaffolding, and modeling. Also, there are some of technical features such as sharing skills to Google Classroom, an audio support, the real-time diagnostic, and trouble spots.

The IXL game supports collaboration among students and teachers through use of Zoom or Google Classroom to deliver IXL lesson activities and assignments (IXL Official Blog, 2020). For example, teachers can assign specific skills related to a lesson of that day and share the link with the whole class to participate in practicing math skills. This online learning provides opportunities for students to share their personal experiences, encourages discussion among students to obtain new knowledge, and increases their motivation to engage more in math activities. Also, by using this game, teachers can provide individual coaching for students who
cannot master some math skills through playing the game by determining the skills that need improvement and provide more practice activities. The IXL website also contains a trouble spots feature that allows teachers to target small groups of students who need further support to develop math skills and have the same level of scaffolding to work collaboratively together on these skills (IXL Official Blog, 2020). This feature can help teachers focus on addressing problems in these skills and helping students improve their skills.

The real-time diagnostic feature enables teachers to track students' progress, review their answers for questions during practice math skill activities, and identify skills that students need to improve. In addition, this feature provides reports on students’ learning progress in the form of visual graphic data and a summary of answered questions, time spent, and scores achieved. This data reporting is useful for exploring students' learning gaps, evaluating students' level of mastery of math skills and performance on assignments, and tracking students' growth.

Moreover, students can use the IXL game at home easily through an audio support feature. This feature would be beneficial for students with vision impairments by providing a simplified audio explanation with detailed steps about how to answer math questions correctly. This feature also helps students who struggle with answering math questions while playing the game and allows them to practice math skills independently at their own pace and discover their mistakes. This feature enhances students' feel of competence and autonomy while answering math questions.

This game can be used for modeling mathematical activities where teachers demonstrate how to use the game to their class by playing with a volunteer student. After modeling, teachers allow all students to try to play the game with their peers. This technique supports students' learning by allowing them to follow the right strategies when practicing math skills and applying
their previous knowledge that they have learned in the classroom. In addition, this way increases students' intrinsic motivation to engage more in doing math tasks.

The IXL game features benefit both genders by encouraging participation and interaction among students while playing the game to support students who are struggling in learning math and enhance their motivation and skills development. It is apparent that the IXL math game features support the intrinsic motivation theory because it includes some of the motivational factors such as competence, positive affect, and autonomy/control.

The IXL math game (Figure 1) was selected because it is designed specifically to meet the objectives of fourth-grade curriculum and allows students to practice math skills. In addition, the math teachers in the Dar Jana International School have tested the IXL game in math classes for one year with their students (girls and boys) to evaluate the effectiveness of this game. The math teachers found that students have mastered math skills and thus their grades were higher than in previous years. Furthermore, students' low motivation and poor performance in math improved after using digital math games because teachers constantly encouraged group work during play and shared with them a report about their progress. Students felt enjoyment in doing math tasks/activities and were interested to learn new knowledge. As a result, the school adapted this game in teaching math subjects. In the math classroom, the teacher uses this game with students after lessons if math lessons are difficult and might require some additional exercises to fully grasp the content. Accordingly, students play the games for the purpose of practicing their math skills twice a week at school or home for an hour or more depending on their understanding of the lessons that had been taught in school during that week.
Chapter Summary

Through reviewing the available scholarly literature, I found that most empirical studies were conducted on the use of digital games-based learning by elementary-school students in developed countries, while there was a scarcity of studies that discussed elementary education in Saudi Arabian schools. This gap in the literature calls for research to be conducted to investigate the effects of using digital game-based math learning on elementary students' motivation in Saudi Arabian schools. To contribute to the limited body of research in developing countries, this study examined how the integration of a digital math game could motivate fourth-grade students to learn math at elementary schools in Saudi Arabia. Additionally, the synthesis of relevant literature revealed that the empirical research has not examined gender segregation in the Saudi Arabian education system at all the different stages of K-12 education. In this regard, the current study explored whether there is a gender difference in terms of motivation to learn math when digital game-based math learning is introduced and used in schools.
CHAPTER 3

METHODOLOGY

This chapter presents the overall methodology that was used in this study. Quantitative research via pre-test and post-test surveys was utilized to examine the effects of using digital math games on fourth-grade elementary students' motivation to learn math in Saudi Arabia. This study also focused on the effect of gender differences on their motivation to learn math. The chapter is organized as follows: research design, participants, survey instruments, validity and reliability of instrument, ethical consideration, research procedures and data collection, data analysis, variables, and potential threats to research validity.

Research Design

This quantitative research employed a quasi-experimental design using a pre-test and post-test approach. This design was chosen for this current study because is a proper method to address the quantitative variables and research questions, and the pre-and post-test allowed the researcher to compare motivation scores before and after the intervention was conducted. According to Creswell (2012), quasi-experimental research refers to the process of comparison between two groups of participants in which they are not randomly assigned to the treatment/experimental group or the control group. Furthermore, in quasi-experimental designs, the treatment group receives an intervention while the comparison group does not.

In this study, 200 students were drawn from eight classes of Grade 4 at the Dar Jana
International School in a Saudi Arabian city. Each class consisted of 25 students: four classes (two comprised of all boys and two comprised of all girls) were assigned to the treatment group. Students in all four classes engaged in the IXL math games during the math lessons. The other four classes (two comprised of all boys and two of all girls) were the comparison group that used a traditional curriculum during the math lessons. The same content was taught to both groups. Girls' and boys' classrooms are separated in different buildings, so during the research period, I administered the survey in the girls' classes with the teachers while the male teachers oversaw the boys' classes.

**Selection of the IXL Game as the Treatment**

The IXL math game is a valuable website that can be easily embedded in remote learning through different types of platforms such as Zoom and Google Classroom (IXL Official Blog, 2020).

The IXL math game was selected because the instructional features (coaching and modeling) and the technical features (an audio explanation and the real-time diagnostic) make the IXL a unique math game for Grade 4 and it differs from other math games. First, it is designed specifically to meet the objectives of fourth-grade curriculum and allows students to practice math skills. Second, the IXL game is a free real-time diagnostic that provides audio explanation support. Teachers are able to monitor students' learning and progress when doing math activities during class sessions through the real-time diagnostic feature. Third, the IXL provides audio explanation support for students if they answer a question incorrectly. The math teachers can use this game for modeling mathematical activities and individual coaching (IXL Official Blog, 2020). It is a powerful motivation tool for helping students engage with colleagues.
in collaborative activities and share experience, whether at school or at home. All these features of the IXL game provide students opportunities to gain in-depth understanding of abstract math concepts, build new knowledge, and become critical thinkers.

In the math classrooms, the teacher uses this game with students after lessons if lessons were difficult and might require some additional exercises to fully grasp the content. Students played the math games twice a week at school or home for an hour or more, depending on students' understanding of the lessons that had been taught in school during that week.

Participants

The target population for this research was all elementary students at Dar Jana International School in Saudi Arabia. The total number of the target population was 498 students of fourth-grade level. The sample consisted of 200 students; 100 were boys and 100 were girls drawn from the population of elementary-school students. The ages of participants were 10 and 11 years old. This age group was chosen because they are competent enough to take the survey individually without additional guidance from teachers. The sample was selected utilizing a convenience sampling method because participants were available and their characteristics were convenient for the purpose of this study. From the sample, the research randomly assigned two boys' classes and two girls' classes to the treatment group and two boys' classes and two girls' classes for the comparison group for a total of eight classes. A total number of four math (two males and two females) participated in this study. Different teachers taught the comparison and treatment groups. In detail, in the boys' section, one male teacher taught the treatment group while the other male teacher taught the comparison group. In the girls' section, one female teacher taught the treatment group while another female teacher taught the comparison group.
Data for this research study were collected from 200 fourth-grade elementary students using the pre-test and post-test survey questionnaire instrument from the TIMSS study. The TIMSS study questionnaire is an international assessment that has been designed by the International Association for the Evaluation of Educational Achievement (IEA) to assess the mathematics and science achievement for fourth- and eighth-grade students (National Center for Education Statistics, 2013). The TIMSS survey includes a motivational scale measuring students’ motivation such as Students Like Learning Mathematics (SLM) which measures students’ intrinsic motivation (Mullis & Martin, 2017). According to Mullis, Martin, Foy, Kelly, and Fishbein (2020); Marsh et al. (2013), the TIMSS survey falls within the framework of motivation theory, as it contains elements to measure intrinsic motivation. For instance, the SLM scale only measures positive affect by all nine items that ask students questions about liking or disliking learning math, if they were interested in and enjoyed work in different subjects, and if they looked forward to learning math, which is one of the intrinsic motivation factors (Marsh et al., 2013). Accordingly, for the purpose of this study, I utilized the SLM motivational scale.

This survey was chosen because the motivational aspects of measurement are aligned with the positive affect factor of the intrinsic motivation theoretical framework selected for this study. In addition, as my research questions focus on how the use of digital math games impact students' motivation to learn math, the utilization of this questionnaire helped to measure the students' level of intrinsic motivation.

Intrinsic motivation arises from internal factors that foster self-motivation of a person, which are a sense of competence accompanied by a sense of autonomy and positive affect and
enjoyment feelings when doing interesting activities. The IXL math games could be a good example for supporting intrinsic motivation theory because it is associated with some of the motivational factors including competence, positive affect (interest), and autonomy/control. For example, it offers a motivational and collaborative environment through providing interactive and challenging questions to reach specific scores for mastering skills and allows students to share their personal experiences while interacting with other groups during math tasks. Within this learning process, students gain new knowledge/experience and build on previous experiences. Also, the challenging questions or tasks motivate students to address the challenges and thus make them deeply engaged and feel enthusiasm and satisfaction about themselves in completing challenging tasks. This is a way to make students be intrinsically motivated to play the game and achieve competence and positive affect factors. Also, another aspect of the IXL math game is it allows students to feel autonomy/control by asking challenging questions that put them into a decision-making condition, where students have freedom to choose suitable strategies by themselves for answering these questions that involve solving problems. Besides, students have control on deciding how to interact with content. These features of the game are considered intrinsic motivators to help students stay engaged and intrinsically motivated while practicing math skills using games.

In the same way, the IXL math game is related to the SLM instrument questionnaire because it is designed specifically to assess intrinsic motivation, including some items that explore the positive affect factor of intrinsic motivation. Using this questionnaire allowed me to determine if students were intrinsically motivated by this intrinsic motivation factor. In conclusion, there is alignment among the instrument, game, and intrinsic motivation theory used in this study.
The SLM includes nine Likert-scale items that measure "positive affect" (Table 1). The questionnaire used a 4-point Likert scale coded as: 1 = disagree a lot, 2 = disagree a little, 3 = agree a little, and 4 = agree a lot. The total (composite) score was computed as the average (mean) of the item scores. For the SLM survey, each student had a pre-test score and a post-test score as the outcome variable. The pre-test score was the average (mean) of nine scores from the nine questions of SLM before using digital math games in teaching math. The post-test score was the average (mean) of nine scores from the nine questions of SLM after using digital math games.

Table 1

Items on the Students Like Learning Mathematics Scale

<table>
<thead>
<tr>
<th>How much do you agree with these statements about learning mathematics?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I enjoy learning mathematics.</td>
</tr>
<tr>
<td>2. I wish I did not have to study mathematics. *</td>
</tr>
<tr>
<td>3. Mathematics is boring. *</td>
</tr>
<tr>
<td>4. I learn many interesting things in mathematics.</td>
</tr>
<tr>
<td>5. I like mathematics.</td>
</tr>
<tr>
<td>6. I like any schoolwork that involves numbers.</td>
</tr>
<tr>
<td>7. I like to solve mathematics problems.</td>
</tr>
<tr>
<td>8. I look forward to mathematics lessons.</td>
</tr>
<tr>
<td>9. Mathematics is one of my favorite subjects.</td>
</tr>
</tbody>
</table>

Note. Response options are 1 = disagree a lot, 2 = disagree a little, 3 = agree a little, and 4 = agree a lot. *Reverse coded.
The questionnaire was checked for negative items: two items were found as negatively worded items that need to be reversed prior to analyses. The two negatively-worded items of SLM, “I wish I did not have to study mathematics” and “Mathematics is boring,” were reverse coded; i.e., the values were coded in the opposite direction (given a new score). The response to a 4-point Likert scale was scored as usual (1 = disagree a lot, 2 = disagree a little, 3 = agree a little, and 4 = agree a lot), but when reverse coded, the negative items were recoded as 4 = disagree a lot, 3 = disagree a little, 2 = agree a little, and 1 = agree a lot.

The survey was delivered via Qualtrics, a web-based survey tool. The pre- and post-test survey instruments included demographic characteristics (gender and ethnicity) and the nine items that asked students about their motivation toward learning math (Appendix A). The questionnaire took approximately 15 minutes to complete. In the second week of the school semester, the pre-test survey was given to all four groups, two comparison groups and two treatment groups for both genders (boys and girls). The post-test survey was given to both comparison and treatment group students at the same time. Students in the treatment group only had used the math game for about a month. The post-test survey contained the same items as the pre-test survey and were focused on students' intrinsic motivation after playing the math games. The purpose of the surveys was to define whether the students’ motivation changed from the pre-survey to the post-survey periods.

Validity and Reliability Evidence for the Instrument

Validity is “the development of sound evidence to demonstrate that the intended test interpretation matches the proposed purpose of the test” (Creswell, 2012, p. 630). To enhance the validity of the instrument in this study, I adopted the SLM questionnaire from the TIMSS study
that had been tested globally in other studies with different populations, sample sizes, and countries (e.g., Arikan, Van de Vijver, & Yagmur, 2016; Kadijevich, 2008; Marsh et al., 2013). The method of validity used in the current study was face validity. To ensure the face validity, two experts examined the content validity of the questionnaire before data collection: NIU's Institutional Review Board office (IRB) and a professor in the Educational Technology, Research and Assessment (ETRA) Department. Additional evidence regarding the reliability of scores obtained from the SLM is based on Kadijevich's (2008) results, which indicated the internal consistency reliability (Cronbach’s alpha) for the SLM scale was above 0.90. Furthermore, according to the 2015 TIMSS study's results of the reliability of the instrument administered, the Cronbach’s alpha score in Saudi Arabia was 0.85 and in the United States was 0.91 (Martin, Mullis, & Hooper, 2016).

In assessing a Likert scale reliability, Cronbach's alpha test was performed to measure the level of internal consistency reliability among survey items and how each single item related to one another. The reliability means that the results of scores remain stable and consistent even if the instrument is repeated many times (Creswell, 2012). Accordingly, in the present study, Cronbach's alpha was calculated for the data obtained separately for both a pre- and a post-test survey to examine internal consistency. Cronbach’s alpha value for the positive affect factor (Like Learning Math) scale for the pre-test and for the post-test indicated an excellent reliability evidence for the scale, as shown in Table 2.
Table 2

Test of the Reliability of SLM Instrument for the Pre- and Post-Tests

<table>
<thead>
<tr>
<th>Factors</th>
<th>Cronbach's Alpha</th>
<th>Number of Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liking Learning Math (positive affect) for pre-test</td>
<td>.908</td>
<td>9</td>
</tr>
<tr>
<td>Liking Learning Math (positive affect) for post-test</td>
<td>.907</td>
<td>9</td>
</tr>
</tbody>
</table>

Ethical Considerations

Before starting the data collection process, I applied for approval from the NIU Institutional Review Board office (IRB; see Appendix B). Then, I needed permission from the site administrators before entering the site (Dar Jana International School) (see Appendix C) and the participants' parents, as the students are considered as minors. The consent forms were prepared for the parents of participants in order to obtain the parents' permission for their child to participate in this study (see Appendix D). Accordingly, I prepared permission forms for the gatekeeper detailing the information about the project and explaining the need for accessing the research site. Also, I prepared a child assent form for the children who were the participants and they had a choice of either signing the assent form or not (see Appendix E). I informed the participants that their participation was voluntary and withdrawal options were up to the participants at any time without penalty. Furthermore, they were notified that it was not required to write their name or ID number on the survey. Also, I took into account some ethical issues such as respect and confidentiality of data. The information obtained from the participants was
only handled by myself and students' responses will be kept confidential and saved in a safe place on a flash drive protected with a password for three years.

Research Procedures and Data Collection

Once I received the NIU IRB approval letter and permission from the Dar Jana International School to conduct this research study, I sent a written parental consent form via email to the school principal to forward the form to the potential participants' parents to obtain their agreement. Then, the school principal sent the form to the parents. This consent form included an explanation of the purpose of the study, data collection procedures, potential participation risks, and the researcher's contact information (i.e., telephone and email). After receiving signed consent forms from parents, I scheduled the initial meeting for the pre-intervention survey that took place at the computer lab of the school. Then, the online survey link directly was emailed to both female and male math teachers who were responsible for sending it with their students.

In the second week of the school semester (on September 17, 2019), the pre-intervention was held during a math class using a computer lab room. At the intervention time, the math teacher and I prepared a computer lab room and opened the survey link for the students. Then the child assent form was distributed to the participants to sign and the math teacher read the form before the intervention began. After signing the assent form, all four groups (two comparison groups and two treatment groups [boys and girls]) started taking the pre-survey at the same time. The students completed the survey in about 20 minutes because students needed clarification on some survey items. No students in both groups who had completed the pre-survey were exposed to math games.
For one month, students in treatment groups used digital math games while comparison groups followed a traditional curriculum. On October 20, 2019, I scheduled a meeting for the post-intervention survey for all 200 students in both groups. This intervention process followed the same procedure as the pre-test intervention. During the post-test time, the students of both genders completed the online survey in approximately 15 minutes. During the data collection, I managed the pre- and post-intervention with the teachers in the girls' classrooms while the male teachers managed the boys' classes. Overall, the data collection process took approximately six weeks. Table 3 shows the research procedure timeline for the study.

Table 3

Research Procedure Timeline

<table>
<thead>
<tr>
<th>Items</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Submit application to NIU Institutional Review Board (IRB)</td>
<td>August 1, 2019</td>
</tr>
<tr>
<td>Send a permission form to school for getting approval to access the research site</td>
<td>August 25, 2019</td>
</tr>
<tr>
<td>Send a parental consent form to participants' parents</td>
<td>August 28, 2019</td>
</tr>
<tr>
<td>Distribution of pre-survey questionnaires via online tool to participants at school</td>
<td>September 17, 2019</td>
</tr>
<tr>
<td>Distribution of post-survey questionnaires via online tool to participants at school</td>
<td>October 20, 2019</td>
</tr>
<tr>
<td>Analyze the data</td>
<td>February 1, 2020-June 18, 2020</td>
</tr>
</tbody>
</table>
Data Analysis

Analysis of the data was completed using the Statistical Package for the Social Sciences (SPSS) software. Also, two data analysis methods were applied for analyzing the research data derived from the surveys. First, to analyze RQ1, repeated-measures ANOVA was used to detect whether there was a statistically significant difference between the two groups in their pre-test and post-test scores in terms of motivation scores. Second, to assess the effect of gender and the effect of digital math games on motivation scores (RQ2), two-way factorial ANOVA was utilized, using the motivation growth scores (pre-test to post-test scores) as the dependent variable and using gender and use of digital math games as the independent variables (factors). Statistical power for the repeated-measures ANOVA was .97, assuming an average effect size and using .05 level of significance.

Variables

This study had two independent variables: gender (boys and girls) and use of digital math game. The dependent variable was motivation growth scores (pre-test and post-test).

Potential Threats to Research Validity

It was assumed that some students may not complete the survey or continue participating in the study between the pre-survey and post-survey. These potential changes might have influenced the outcome of the data, which is defined as a threat to internal validity. This potential threat was assessed and controlled by giving each student who completed both surveys a chance to win 10 Saudi riyal (SAR) cash.
However, a threat to external validity is that the results are not generalizable because the participants were limited to only for fourth grade from one elementary school in Saudi Arabia.

Chapter Summary

In conclusion, this chapter has provided a description of the research design method and the instrument used to collect data from targeted participants ($n=200$). The nine items of the SLM questionnaire were used to measure the fourth-grade students’ motivation level. The result of Cronbach’s alpha obtained from this study data indicated scores for both pre-test and post-test were reliable. To analyze Research Question 1, repeated-measures ANOVA was performed. In addition, two-way factorial ANOVA analysis was applied to analyze results pertinent to Research Question 2. Chapter 4 tackles the details of the results of data analysis as well interpretation of findings of this study.
CHAPTER 4
RESEARCH FINDINGS

The purpose of this quantitative study was to investigate the effect of using digital math games on fourth-grade elementary students' motivation to learn math in Saudi Arabia. This study also focused on the effects of gender differences on their motivation to learn math. This chapter presents screening the data, an overview of interpretation of research results about the participants' demographics, the descriptive statistics, and inferential statistics analyses conducted on the following research questions:

1. To what extent is the use of digital math games related to elementary students' motivation to learn math?
2. To what extent does gender moderate the relationship between the use of digital math games and students' motivation to learn math?

Screening the Data

Before conducting statistical analyses, the data first were carefully screened to check for any missing values. This process showed that there were no missing values. After cleaning the data, I next constructed boxplots to identify any outliers or extreme values in the data. All boxplots shown in Figure 2 for SLM scale scores indicate that the positive affect construct for the pre- and post-test had outliers (i.e., values within 1.5 to 3 times the interquartile range [IQR]) and there were several extreme values (i.e., values more than 3 times the IQR). Because the
outliers were within the range of expected values, these values were retained in the data. To account for the extreme values analyses were conducted both using the extreme values and also carried out after truncating the extreme values so that they were equal to the next lowest value. The conclusions of analyses tests for both research questions were the same as the original analyses, which indicated the conclusions did not change after truncating the extreme values from the data.

Figure 2: Boxplot for SLM scale score for pre-test and post-test.

Reliability Evidence for the Instrument

The computed value for Cronbach’s alpha for the instrument used in this study indicated a high level of internal consistency, with values above 0.70 for the SLM scale of positive affect factor.
1. The reliability of Cronbach’s alpha value for the positive affect factor (Liking Learning Math) of the scale (9 items) for the pre-test was $\alpha = .908$, indicating high reliability of the instrument scores.

2. The Cronbach’s alpha value for the positive affect factor (Liking Learning Math) of the scale (9 items) for the post-test was $\alpha = .907$, indicating high reliability of the instrument scores.

Demographics Data

Descriptive statistics were computed to explore the demographic information of the sample participants. The demographic data included information about gender, race/ethnicity, and using digital math games in school. In the sample of this study, the participants were 200 students in total. They completed both pre- and post-surveys; the treatment group ($n=100$) and the comparison group ($n=100$) were 50% boys and 50% girls. They were fourth-grade elementary students from the Dar Jana International School whose ages ranged from 10 to 11 years old. As shown in Table 4, the majority of the students identified their nationality as Saudi (48.5%) while other students were of different nationalities, specifically, Indian (6.0%), Egyptian (19.5%), and other nationalities (26%). Also, 100 students (50%) in the comparison group reported that they did not use any digital math games during regular school math classes and 100 students (50%) in the treatment group stated that they used digital math games.

Analysis of Research Questions

The following section provides a description of data analysis (descriptive and inferential statistics) for the two research questions, further organized into two sections, respectively. Each
section presents the findings that are relevant to each research question and its related hypothesis as well as its assumptions.

Table 4
Distribution of Demographic of Participants' Characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Using digital math games</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No (the comparison group)</td>
<td>100</td>
<td>50</td>
</tr>
<tr>
<td>Yes (the treatment group)</td>
<td>100</td>
<td>50</td>
</tr>
<tr>
<td>Total</td>
<td>200</td>
<td>100</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boy</td>
<td>100</td>
<td>50</td>
</tr>
<tr>
<td>Girl</td>
<td>100</td>
<td>50</td>
</tr>
<tr>
<td>Total</td>
<td>200</td>
<td>100</td>
</tr>
<tr>
<td><strong>Race/Ethnicity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saudi</td>
<td>97</td>
<td>48.5</td>
</tr>
<tr>
<td>Indian</td>
<td>12</td>
<td>6.0</td>
</tr>
<tr>
<td>Egyptian</td>
<td>39</td>
<td>19.5</td>
</tr>
<tr>
<td>Other</td>
<td>52</td>
<td>26.0</td>
</tr>
<tr>
<td>Total</td>
<td>200</td>
<td>100</td>
</tr>
</tbody>
</table>

**Research Question 1**

1. To what extent is the use of digital math games related to elementary student’s motivation to learn math?
Hypothesis

H0: There will be no difference between the treatment and comparison groups in the change in students’ motivation to learn math.

Descriptive Statistics

The results in Table 5 show a summary of the descriptive statistics for pre- and post-test, including mean and standard deviation for the treatment group (used digital math game) and the comparison group (did not use digital math game). In the treatment group, the students' mean motivation scores in pre-test, \(M = 3.34, (SD) = .75\), were lower than the students' mean motivation scores in post-test, \(M = 3.61, (SD) = .54\). Likewise, in the comparison group, the students' mean motivation scores in pre-test, \(M = 3.34, (SD) = .73\), were lower than the students' mean motivation scores in post-test, \(M = 3.42, (SD) = .72\), respectively.

Table 5
Descriptive Statistics for Pre- and Post-Test

<table>
<thead>
<tr>
<th></th>
<th>Digital math game use</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-test</td>
<td>Use game</td>
<td>3.34</td>
<td>.75</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Not use game</td>
<td>3.34</td>
<td>.73</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>3.34</td>
<td>.74</td>
<td>200</td>
</tr>
<tr>
<td>Post-test</td>
<td>Use game</td>
<td>3.61</td>
<td>.54</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Not use game</td>
<td>3.42</td>
<td>.72</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>3.52</td>
<td>.64</td>
<td>200</td>
</tr>
</tbody>
</table>
Inferential Statistics

To address Research Question 1, a repeated-measures ANOVA was applied to examine whether there was a statistically significant group difference (comparison group vs. treatment group) in the change in motivation scores from pre-test to post-test. The assumption of normality was assessed by examining a histogram of residuals and the Kolmogorov-Smirnov and Shapiro-Wilk test. Motivation growth scores (pre-test and post-test) were dependent variables and digital math games use was the independent variable (fixed factor).

As shown in Table 6, the ANOVA test of the within-subject effect showed that the main effect of time (pre- to post-test change in the fourth-grade student’s motivation to learn math) was statistically significant, with $F(1, 198) = 6.10, p = .014$. This result demonstrated that for the combined groups there was a significant increase in motivation growth scores over time. However, the interactive effect of group type × time on motivation scores was not statistically significant, with $F(1, 198) = 1.85, p = .175$, indicating that there was no group difference in the change over time in scores (see Figure 3). The variances of difference scores were statistically equal across groups.

Additionally, the results of the between-subjects effects showed that there was no statistically significant effect of game use on the overall motivation growth scores, with $F(1,198) = 1.92, p = .167$, indicating no difference between the treatment and comparison groups in the overall motivation growth scores (see Table 7).
Table 6

Tests of Within-Subject Effects for Motivation Scores by Time and the Use of Digital Math Game

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>Sphericity Assumed</td>
<td>3.180</td>
<td>1</td>
<td>3.180</td>
<td>6.10</td>
</tr>
<tr>
<td>Time * Game use</td>
<td>Sphericity Assumed</td>
<td>.967</td>
<td>1</td>
<td>.967</td>
<td>1.85</td>
</tr>
<tr>
<td>Error (time)</td>
<td>Sphericity Assumed</td>
<td>103.192</td>
<td>198</td>
<td>.521</td>
<td></td>
</tr>
</tbody>
</table>

Figure 3. Plots for pre-test and post-test of motivation scores.
Table 7

Tests of Between-Subjects Effects by Use of Digital Math Game

<table>
<thead>
<tr>
<th></th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>4717.400</td>
<td>1</td>
<td>4717.400</td>
<td>10549.982</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Use Game</td>
<td>.861</td>
<td>1</td>
<td>.861</td>
<td>1.92</td>
<td>.167</td>
</tr>
<tr>
<td>Error</td>
<td>88.535</td>
<td>198</td>
<td>.447</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

As seen in Table 8, the Kolmogorov-Smirnov (K-S) and Shapiro-Wilk (S-W) test of the normality of the residuals demonstrated that the normality assumption was not met ($p < .001$). However, the histogram of residuals results revealed that the histogram was close to normally distributed, which suggests the assumption of normality of the residuals has been met (see Figure 4). Moreover, the large sample size mitigated concerns about non-normality.

Table 8

Tests of Normality of the Residuals

<table>
<thead>
<tr>
<th></th>
<th>Kolmogorov-Smirnov</th>
<th>Shapiro-Wilk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Statistic</td>
<td>df</td>
</tr>
<tr>
<td>Pretest</td>
<td>.189</td>
<td>200</td>
</tr>
<tr>
<td>Posttest</td>
<td>.232</td>
<td>200</td>
</tr>
</tbody>
</table>
Research Question 2

2. To what extent does gender moderate the relationship between the use of digital math games and students’ motivation to learn math?

Hypothesis

H0: The difference between treatment and comparison groups in their change in motivation scores will not vary by gender.

Descriptive Statistics

Table 9 presents the descriptive statistics for the change (pre-test to post-test) in motivation scores by gender and digital math games use and Figure 5 shows the mean motivation growth scores by gender and digital math games use.
Table 9

Descriptive Statistics for Growth in Motivation to Learn Math by Gender

<table>
<thead>
<tr>
<th>Digital math game use</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use game</td>
<td>.53</td>
<td>1.05</td>
<td>50</td>
</tr>
<tr>
<td>Not use game</td>
<td>.12</td>
<td>1.10</td>
<td>50</td>
</tr>
<tr>
<td>Total</td>
<td>.32</td>
<td>1.09</td>
<td>100</td>
</tr>
<tr>
<td>Girl</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use game</td>
<td>.01</td>
<td>.74</td>
<td>50</td>
</tr>
<tr>
<td>Not use game</td>
<td>.03</td>
<td>1.08</td>
<td>50</td>
</tr>
<tr>
<td>Total</td>
<td>.02</td>
<td>.92</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use game</td>
<td>.27</td>
<td>.94</td>
<td>100</td>
</tr>
<tr>
<td>Not use game</td>
<td>.08</td>
<td>1.08</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>.17</td>
<td>1.02</td>
<td>200</td>
</tr>
</tbody>
</table>

Figure 5. Plot of mean motivation growth scores by gender and math game use.
Inferential Statistics

To address the second research question, two-way factorial ANOVA analysis was performed to evaluate whether the difference between the treatment and comparison groups in fourth-grade motivation growth scores differed by gender. The normality assumption was assessed through the Komogorov-Smirnov and Shapiro-Wilk tests and examination of histograms of residuals. Box’s test was used to evaluate the assumption of equality of covariances. In this research question, gender and digital math games use were independent variables and the motivation growth score was the dependent variable.

The ANOVA analysis (see Table 10) showed the effect of interaction between gender and the use of digital math games was not statistically significant, $F(1, 196) = 2.30, p = .130$, indicating that the effect of using digital math games on students' motivation to learn math did not differ by gender. However, the main effect of gender on motivation growth scores was statistically significant, with $F(1, 196) = 4.45, p = .036$, indicating that the two gender groups differed statistically significantly, but to a small degree, in their growth in motivation to learn math, with boys showing greater growth than girls. The effect of the use of digital math games on the overall motivation growth scores was not statistically significant, with $F(1, 196) = 1.90, p = .170$, demonstrating that overall motivation growth scores did not differ by group (treatment vs. comparison group). This reveals that the use of digital games did not have a significant effect on the fourth-grade students' motivation towards learning math.
Table 10
ANOVA Results for Effects of Gender and the Use of Digital Math Games on Growth in Motivation to Learn Math

<table>
<thead>
<tr>
<th></th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>8.815$^a$</td>
<td>3</td>
<td>2.938</td>
<td>2.88</td>
<td>.037</td>
</tr>
<tr>
<td>Intercept</td>
<td>6.361</td>
<td>1</td>
<td>6.361</td>
<td>6.24</td>
<td>.013</td>
</tr>
<tr>
<td>Gender</td>
<td>4.533</td>
<td>1</td>
<td>4.533</td>
<td>4.45</td>
<td>.036</td>
</tr>
<tr>
<td>Game</td>
<td>1.934</td>
<td>1</td>
<td>1.934</td>
<td>1.90</td>
<td>.170</td>
</tr>
<tr>
<td>Gender * Game</td>
<td>2.347</td>
<td>1</td>
<td>2.347</td>
<td>2.30</td>
<td>.130</td>
</tr>
</tbody>
</table>

To assess the homogeneity of variance assumption, Box’s test was employed. As presented in Table 11, the result of Box’s test was statistically non-significant, with $F(3, 7056720) = 2.59, p = .051$, indicating that the variance/ covariance of the dependent variables between groups was equal and that the assumption of homogeneity of covariance was met.

Table 11
Box's Test of the Homogeneity of Variance Matrices

<table>
<thead>
<tr>
<th></th>
<th>Box's M</th>
<th>$F$</th>
<th>$df_1$</th>
<th>$df_2$</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Box's M</td>
<td>7.878</td>
<td>2.59</td>
<td>3</td>
<td>7056720.000</td>
<td>.051</td>
</tr>
</tbody>
</table>

To assess the normality assumption, Kolmogorov-Smirnov and Shapiro-Wilk test were applied and a histogram of residuals constructed. As presented in Table 12, the Kolmogorov-
Smirnov and Shapiro-Wilk test results demonstrated that the normality assumption was not met \((p = .012)\). However, the histogram of residuals results revealed that the histogram was close to normally distributed, which suggests the assumption of normality of the residuals was met (see Figure 6). Moreover, the large sample size mitigated concerns about non-normality.

Table 12

Tests of Normality of the Residual

<table>
<thead>
<tr>
<th>Standardized Residual for Motivation Scores</th>
<th>Kolmogorov-Smirnov</th>
<th>Shapiro-Wilk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Statistic</td>
<td>.089</td>
<td>.982</td>
</tr>
<tr>
<td>df</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>Sig.</td>
<td>.001</td>
<td>.012</td>
</tr>
</tbody>
</table>

Figure 6: Histogram of standardized residuals.
Chapter Summary

This chapter presented the findings from the data analysis in relation to the two research questions. Descriptive statistics and inferential statistics of two-way ANOVA and repeated-measures ANOVA were used to determine the effects of digital math games on the motivation level of fourth-grade students. In general, the results of the current study showed no statistically significant effect for the use of digital math games on intrinsic motivation. Additionally, the results showed that there was a significant increase in scores over time from the pre- to the post-tests in the students’ motivation scores to learn math in both the treatment group who used the digital math games and the comparison group who did not use the digital math games. However, boys and girls were different in their growth in motivation to learn math when they played the digital math games, suggesting that boys became more highly motivated to learn math than the girls. Boys and girls did not differ significantly, however, in the effect of using digital math games on motivation score growth. Further examination and discussion of these findings are presented in Chapter 5.
CHAPTER 5
DISCUSSION

This chapter will shed a light on the major findings obtained from the data analysis and detail how the findings of this research study are compared to previous studies. This chapter is organized into four sections: discussion of the results, implications, recommendations for future studies, and chapter summary.

This quantitative research through a quasi-experimental design was conducted on 200 students, with 100 of students assigned to comparison group (traditional curriculum) and the other 100 students assigned to treatment group (digital math games). The purpose of this study was to investigate the effects of using digital math games on fourth-grade elementary students' motivation to learn math in Saudi Arabia. This study also focused on the effects of gender differences on their motivation to learn math. Data was collected through using a survey that included nine items to measure the students’ intrinsic motivation toward learning math based on one factor: Students Liking Learning Mathematics (positive affect). The intrinsic motivation theory was utilized as the theoretical framework for this study. The intrinsic motivation consists of the following factors: positive affect, students’ self-confidence, task values, relatedness, and autonomy/control. The present study analyzed the research questions and related hypotheses based on two types of analysis: repeated- measures ANOVA and two-way factorial ANOVA. In the following section, the findings in relation to each research question is summarized and discussed in the light of existing literature and theory used in this study.
Discussion of Findings

Research Question 1

Research Question 1 investigated whether the students' motivation score changed from before to after (the pre- and post-surveys) the use of digital math games by applying a repeated-measures ANOVA analysis.

Examination of the interactive effect of use of digital math games for learning math × time on motivation scores revealed that there was no group difference among fourth-grade students in the change over time in their motivation scores. Additionally, there was no statistically significant effect of game use on the overall motivation scores. This means there is no statistically significant difference between treatment and comparison groups in either the overall motivation scores or the motivation growth scores. Consequently, it can be concluded that positive affect factor of intrinsic motivation theory may not be directly applicable to the relationship between intrinsic motivation and the use of digital math games. In other words, using digital math games may not have contributed to stimulating the students' intrinsic motivation and their self- positive affect experience toward learning math.

This finding suggests that students might not feel interested in doing math activities/tasks, which might have caused their lack of engagement with the math games. As Isen and Reeve (2005) stated, positive affect factor directly impacts students' intrinsic motivation and interest as well as influences their engagement with content. The results of this study were aligned with the findings of Kebritchi, Hirumi, and Bai (2010), who found that mathematics games did not demonstrate any significant effect on students’ motivation when comparing between a control group who did not play the math games to an experimental group who played
the math games. On the same note, the result of this study was consistent with Kapper's (2009) study, which found that using an educational video game in mathematics class could fail to promote students’ motivation for both boys and girls.

However, some studies (e.g., Chen, Lin, Looi, Shao, & Chan, 2012; Hwang, Wu, & Chen, 2012) have shown the opposite findings of the current study findings. For instance, Chen, Lin, Looi, Shao, and Chan’s (2012) study reported that when students used the math game in an elementary math class, there was a difference among students who played the game because they were highly motivated and had better performance compared to the control group who did not play the game. Also, Hwang, Wu, and Chen's (2012) findings indicated that there was a statically significant difference between experimental and control groups. The students who used the online web-based problem-solving game approach had a significantly higher intrinsic motivation and learning interest, thus achieved better performance than those who learned with the traditional web-based learning approach.

On the other hand, results from the analysis did show that there was statistically significant overall growth in motivation scores for both groups. Specifically, in the treatment group, the mean motivation score for pre-test was 3.34 points compared to the mean motivation score for post-test of 3.61 points. Students' mean motivation score for the comparison group increased a similar amount from the pre-test to post-test, from 3.34 points to 3.42 points. Accordingly, these findings indicated that intrinsic motivation scores for two groups increased over time. This result was aligned with Habgood and Shaaron's (2011) study which found that the mean of students' intrinsic and extrinsic motivation scores for both groups (experimental and control) significantly increased from pre-test to post-test. In contrast, this result was not consistent with the findings of Huang and Ke (2009), who discovered that the difference between
the two groups (experimental and control) in their motivation and achievement scores was statistically significant. The results showed that after the instruction the experimental-group students who used math games integrated into math classroom activities had a significant improvement in motivation, achievement, and a more positive attitude toward learning mathematics compared to a traditional learning environment.

Research Question 2

Playing digital games is one of the preferred activities for both boys and girls in today's society; however, boys are more likely to play them than girls (Chung & Chang, 2017). The issue regarding gender differences is still critical for many researchers; therefore, this study investigated whether gender moderated the effect of playing digital math games on students' motivation. The main findings generated from this study found no statistically significant moderation effect of gender on the effect of digital math games on motivation growth scores. This evidence suggests that the effect of using digital math games on students' intrinsic motivation to learn math did not differ by gender.

In contrast, other findings illustrated that gender had a significant effect on fourth-grade students' intrinsic motivation for learning math. Based on that, gender differences regarding their motivation score growth was examined. When gender mean differences were compared, the results showed that there was a statistically significant gender difference in the mean motivation growth scores of boys and girls, where boys scored higher than girls, although the magnitude of the mean difference was small. For example, the overall mean of motivation score growth (pre-test to post-test) for boys was 0.32, whereas the overall mean of motivation score growth for girls was 0.02. This finding indicates that boys were more intrinsically motivated and became more
highly engaged in math activities than girls. Additionally, boys showed more enjoyment in playing digital math games compared to girls, who seemed to have had less interest and enjoyment. This result proved that both genders had different levels of intrinsic motivation towards learning math. This finding was supported by Yang and Chen's (2010) study that reported that boys significantly outperform girls in performing mathematics tasks. Also, the findings of this study agreed with Fahuzan and Santos's (2018) findings that showed the male students’ motivation was significantly higher than the female students’ motivation in learning math using a smartphone game. However, the findings of this study disagreed with Mavridis, Katmada, and Tsiatsos's (2017) study, in which they found no significant gender difference among girls and boys regarding their motivation towards learning mathematics in solving problems when playing an online flexible educational math game. Moreover, Chung and Chang (2017) found that there was no significant gender difference among the fourth-grade students' motivation and learning achievement in learning math after using an educational video game and also the gender did not impact students' motivation and learning achievement.

In addition, the effect of the use of digital math games on motivation growth scores in this analysis was not statistically significant, demonstrating that overall mean motivation score growth did not differ by group (treatment vs. comparison group). This result aligns with the findings from RQ1 that the use of digital math games did not have a significant effect on fourth-grade students' intrinsic motivation towards learning math.

Implications

Math is a problem for many students because it is a difficult subject and usually needs high levels of thinking and problem-solving skills that many students often are afraid of and feel
powerless about their abilities to solve mathematical problems (Jones, 2015). Thus, to change this negative perception among students, it is very important to properly integrate math games into teaching to help students overcome their fear. In this study, the IXL math game was used because math teachers at the Dar Jana International School adopted this game into the math curriculum as a motivational tool to stimulate students who lacked motivation and had low performance. Accordingly, the IXL game was chosen for this study because of its instructional features such as coaching, exploring, scaffolding, and modeling and it was already being tested by math teachers. In addition, the IXL game might enhance intrinsic motivation, i.e., competence, positive affect (interest), and autonomy/control.

The findings of this study demonstrated that the fourth-grade students' intrinsic motivation toward learning math increased after using the digital math game (IXL) over time from pre-test to post-test. However, because the motivation scores of those students who did not use the game increased by a similar amount, the results also showed that digital math games did not significantly affect the students' overall motivation to learn math. Limited time exposure to playing math games (for once or twice a week) was deemed to be the main factor that affected measuring the overall effectiveness of the game.

The findings of this study are essential for math teachers who are planning to integrate math games as supportive educational tools in the teaching process; they need to incorporate the games into the math curriculum and align them with lesson plans so students have frequent exposure to the math activities. This process helps teachers ensure that students fully understand content and master prerequisite math skills. Also, to increase the students' intrinsic motivation in learning math through games, teachers should provide a chance for students to play math games as groups rather than individually to help them actively engage with peers in collaborative
activities. In addition, teachers must provide challenging questions targeting the score level required for mastering the math skills on each level of the game. Promoting group work and challenging questions nourishes the students’ intrinsic motivation, interest, and personal experience in learning math. Furthermore, the schools should allot additional time and encourage teachers to use digital math games with students in the classroom instead of playing at home. Thus, the teachers can observe the students and support them if they need help while playing.

The results showed that there was a gender difference in the mean intrinsic motivation scores among boys and girls in both groups, in that the boys scored slightly higher than the girls. Accordingly, teachers must identify the weaknesses in math skills that girls need to improve. In addition, teachers should provide further mathematics practice activities and encourage group working among girls who have low motivation to learn math to enhance their skills and increase their intrinsic motivation to learn math.

The Saudi Arabian education system is currently in the stage of improving K-12 education by incorporating educational technology tools, such as using digital games-based learning, in the teaching process. This idea is still under review by decision makers at the Ministry of Education. Although the results of this study showed that the IXL game did not affect students' intrinsic motivation to learn math, the instructional features (coaching, exploring, scaffolding, and modeling) of the IXL game may provide opportunities for students to gain in-depth understanding of abstract math concepts and improve their math skills, particularly problem-solving skills, where they are able to address math problems as creative mathematical thinkers. Moreover, this game includes some motivational factors that may enhance intrinsic motivation (competence, positive affect [interest], and autonomy/ control) that in turn makes students intrinsically motivated to learn math. Consequently, this result underlines the use of
digital math games in regular public schools in Saudi Arabia as a supplementary tool for facilitating teaching math and to meet the needs and interests of today’s students. Providing a digital game-based learning environment may increase students' engagement and make the learning of math more pleasant for students compared to the traditional environment. Therefore, the decision makers at the Ministry of Education in Saudi Arabia should create a collaborative team of game designers and math teachers to develop educational games that meet the requirements of the curriculum to ensure student success in learning mathematics.

Recommendations for Future Research

This research study provides some recommendations for future research on related topics. In reviewing seminal studies about using digital game-based math learning in Saudi Arabia, I found only limited resources in regard using games in Saudi education. Thus, this study recommends conducting empirical studies in this area. Since this study investigated the effect of using digital math games on students' motivation only from the students' perspective, it is important for future studies to examine Saudi teachers' attitudes toward integrating digital math games in their classrooms.

The current study carried out a quantitative method using survey for collecting data. For future studies, I recommend conducting a mixed-method study involving quantitative and qualitative methods with a combination of an open-ended questionnaire survey with semi-structured interviews for collecting data. Because the result of this study reported that the effect of using digital math games on motivation was not statistically significant, further investigation about the effects of the math games on students' motivation is needed. This mixed method might
present different results and provide in-depth interpretations of whether the use of digital math
games is effective in strengthening students' motivation to learn math.

Lastly, this study selected participants from only one school level, which was elementary
(fourth-grade) students of the same age and learning abilities from a single school in Saudi
Arabia. There is a need for further research with a large sample size including participants from
different levels schooling, such as elementary, middle, and high schools and from different
settings (e.g., public or private schools). Future studies with different levels of schooling might
provide different results that could be generalized in various grade levels. These results might
contribute to adapting digital game-based learning in all school stages in Saudi Arabia.

Limitations

This study had some limitations in regard to the generalizability of findings. The first
limitation of this study was the reliability of the findings that might have been affected by the
honesty of the participants' responses to the survey questions due to their knowledge of
English. The participants' low level of proficiency in the English language may have contributed
to their misunderstanding of some survey items as English is considered a second language in
Saudi Arabia. The second limitation of this study was that participants were from one
international school in Saudi Arabia. Therefore, the findings of this study cannot be generalized
to a larger population because the findings were based on the perceptions of only 200 elementary
students surveyed from one location. The third limitation was the length of time for collecting
data, which was confined to only six weeks. A longer time might generate different results.
Chapter Summary

The goal of this study was to investigate the effects of using digital math games on fourth-grade elementary students' motivation to learn math in Saudi Arabia. This study also examined the effects of gender differences on students' motivation to learn math. In this study, students' motivation was measured by intrinsic motivation theory based on the positive affect factor (Students Liking Learning Mathematics). This factor of intrinsic motivation was evaluated twice through a pre- and post-survey questionnaire. In the pre-survey, the 100 students in the comparison group, who used traditional approach, and the 100 students in the treatment group, who used the IXL math games, were surveyed before the intervention occurred. After the intervention, both groups were surveyed again to compare changes in their intrinsic motivation scores. Through the analysis of repeated-measures ANOVA, I discovered that there were differences in motivation growth scores when comparing the means between pre-test and post-test, showing that the mean score for both groups increased over time. However, comparing the comparison and treatment groups on their change in motivation scores over time did not reveal any significant group difference.

Overall, the results regarding the effect of using digital math games and gender on students' intrinsic motivation demonstrated that the effects of math games on motivation was not a statically significant, whereas gender was related to students' motivation, as boys became more highly motivated to learn math over time than girls.
BIBLIOGRAPHY


APPENDIX A

SURVEY QUESTIONNAIRE
DEMOGRAPHIC QUESTION

Q1 What is your gender?
   ○ Boy
   ○ Girl

Q2 What is your race/ethnicity?
   ○ Saudi
   ○ Indian
   ○ Egyptian
   ○ Other, please indicate ______________________

Q3 Have you used math-based learning games before?
   ○ Yes
   ○ No
STUDENTS LIKE LEARNING MATHEMATIC SCALE

Q4 How much do you agree with these statements about learning mathematics? Fill one circle for each line

<table>
<thead>
<tr>
<th>Items</th>
<th>Agree a lot (1)</th>
<th>Agree a little (2)</th>
<th>Disagree a little (3)</th>
<th>Disagree a lot (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I enjoy learning mathematics</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I wish I did not have to study mathematics</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Mathematics is boring</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I learn many interesting things in mathematics</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I like mathematics</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I like any schoolwork that involves numbers</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I like to solve mathematics problems</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I look forward to mathematics lessons</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Mathematics is one of my favorite subjects</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>
 Approval Notice
Initial Review

26-Aug-2019

TO: Rania Koluandy (01749255)
Educational Technology, Research and Assessment

R.E: Protocol # HS20-0019 “Effects of digital game-based learning on students' motivation in math classes”

Your Initial Review submission was reviewed and approved under Member Review procedures by Institutional Review Board #1 on 20-Aug-2019. Please note the following information about your approved research protocol:


If your project will continue beyond that date, or if you intend to make modifications to the study, you will need additional approval and should contact the Office of Research Compliance and Integrity for assistance. Continuing review of the project, conducted at least annually, will be necessary until you no longer retain any identifiers that could link the subjects to the data collected. Please remember to use your protocol number (HS20-0019) on any documents or correspondence with the IRB concerning your research protocol.

Please note that the IRB has the prerogative and authority to ask further questions, seek additional information, require further modifications, or monitor the conduct of your research and the consent process.

Unless you have been approved for a waiver of the written signature of informed consent, this notice includes a date-stamped copy of the approved consent form for your use. NIU policy requires that informed consent documents given to subjects participating in non-exempt research bear the approval stamp of the NIU IRB. This stamped document is the only consent form that may be photocopied for distribution to study participants.

It is important for you to note that as a research investigator involved with human subjects, you are responsible for ensuring that this project has current IRB approval at all times, and for retaining the signed consent forms obtained from your subjects for a minimum of three years after the study is concluded. If consent for the study is being given by proxy (guardian, etc.), it is your responsibility to document the authority of that person to consent for the subject. Also, the committee recommends that you include an acknowledgment by the subject, or the subject's representative, that he or she has received a copy of the consent form. In addition, you are required to promptly report to the IRB any injuries or other unanticipated problems or risks to subjects and others. The IRB extends best wishes for success in your research endeavors.
APPENDIX C

SCHOOL PERMISSION
To The Saudi Cultural In United State-DC,

The Administration of Dar Jana International School grants Ms. Rania Abdulkaroon Kokandy, a Saudi citizen holding ID number: 123456789, the permission to conduct surveys (Apre and a post survey questionnaire for Grade 4 students) and collect the necessary data from the pre designed and attached questionnaire.

This approval is effective immediately and during the first semester. Any information collected from our school should remain confidential and used for the research purpose only.

This approval is issued upon her request for whatever purpose it may serve her best, and with no liability on our behalf.

School Administration
APPENDIX D

PARENTAL CONSENT FORM
This is a parental consent form will give you information about the study to decide whether or not to allow your child to participate in a research study. Please read this form carefully before you decide to give your permission. If you agree, please sign this form to confirm your decision you will receive a copy of signed form for your records. If you may refuse that your child not to be involved in this study, there is no penalty or loss of any benefits. Participation of your child to the study is completely voluntary and you child can withdraw from the study at any time.

The purpose of this research study is to investigate whether using digital games for teaching math can increase the 4th grade Saudi Arabian elementary school students’ motivation to learn math.

If you allow your child to participate in this study, your child will be asked to complete two online surveys questionnaire (pre- and post-survey) during regular math classroom. The questionnaire will take around 15-20 minutes to complete. In the second week of the school semester and the post-survey will be given to students’ participants after they use the math game about a month.

During research intervention, there will not foreseeably risks to your child in this study. Participants will receive an incentive for participation of 10 SR cash upon completion of both surveys. The collected data will be kept confidential and be used by the researcher only.

If you have any questions or concerns regarding participation or your child’s rights as participant in this study, please contact Rania Kokandy at phone [redacted] or send an email to [redacted]

The signature below indicates that you have acknowledged reading the information provided above and have decided to allow my child to participate in the study. You will also receive a copy of this form for your records.

Child’s name (please print):
____________________________________________________________

Parent’s name (please print):
____________________________________________________________

Signature: ____________________________________________ Date _____ / _____ / _____

APPENDIX E

CHILD ASSENT FORM
The purpose of this research study is to investigate whether using digital games for teaching math can increase the 4th grade Saudi Arabian elementary school students’ motivation to learn math.

You will be asked to complete two online surveys questionnaire (pre- and post-survey) during regular math classroom. The questionnaire will take around 15-20 minutes to complete. In the second week of the school semester and the post-survey will be given to students’ participants after they use the math game about a month. Your answers will be kept private and will not show them to your parent or teacher.

Your participation in this study is completely voluntary. if you do not want to participant or discontinuation of participation you have the right to withdraw from the study at any point, there is no penalty or loss of any benefits. There will not foreseeable risks or problem will happen to you in this study. You will receive an incentive for participation of 10 SR cash upon completion of both surveys. You will also receive a copy of this form for your records.

If you have any questions or concerns regarding participation or your rights as participant in this study, please contact Rania Kokandy at phone [redacted] or send an email to [redacted]

The signature below indicates that you have understood the information provided above and have agree to participate in the study. Your parent will receive a copy of this form for your records.

Name (please print):

Signature: _____________________________________________

Date_______/_______/___________