THE RELATIONSHIP BETWEEN MOTIVATION, ACADEMIC ACHIEVEMENT, AND ENGAGEMENT IN MATHEMATICS USING DIGITAL GAME-BASED LEARNING: AN EXPLANATORY SEQUENTIAL MIXED METHODS STUDY

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DEDICATION

I would like to dedicate this dissertation to my family who has supported me throughout this entire process. Especially my parents, Madeleine and Tom Halter, and my husband, Gregory Morgan. All of you have always supported me pursing my education and have assisted me through the entire process. Thank you! Lastly, I would like to dedicate this my first child who is due in May of 2022 and has already brought me so much joy and inspiration!

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ABSTRACT

Digital game-based learning (DGBL) has unique factors that can engage students in the learning process. It has been shown that incorporating DGBL into mathematics can help bridge the learning gap, differentiate instruction, and engage students (Yang et al., 2018; Hulse et al., 2019; Chen et al., 2012; Naik, 2017). This study examined how students' prior engagements are related to their academic achievement as well as investigated students' motivation while utilizing DGBL in mathematics. An explanatory sequential mixed methods design was utilized to collect the quantitative data followed by the qualitative data. There were eighteen middle school participants in grades six through eight who all attended the same school within the Northeastern United States. The self-determination theory (SDT) served as the theoretical framework for examining the results.

Data was collected through a pretest, posttest, an open-ended survey, and a closed-ended survey. The results of this study indicated that DGBL can improve academic achievement in mathematics. However, it was determined that students' prior engagement was not related to their academic achievement. Additional research should be conducted on the motivational aspect of relatedness and DGBL since it was shown that there was a strong correlation between relatedness and the engagement themes of learning with peers and experiences with faculty.

Keywords: Digital game-based learning, academic achievement, engagement, motivation, middle school, mathematics

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LIST OF ABBREVIATIONS

DGBL	Digital Game-Based Learning
NSSE	National Survey of Student Engagement
CSDT	Center for Self-Determination Theory
SDT	Self-Determination Theory

CHAPTER ONE: INTRODUCTION

Introduction

Educators are responsible for creating learning environments that give students opportunities to grow and learn intellectually as well as socially. This simple sentence may sound like a basic task, however, teachers are overwhelmed with growing class sizes with students of varying needs and abilities (Blatchford & Russell, 2019). Teachers of all subject areas in K-12 education are constantly struggling to develop new and innovative ways to engage students in learning while improving academic achievement. Mathematics is a cumulative subject area that has concrete right or wrong answers, which makes it especially challenging to create engaging lessons to meet the needs of all the learners. To combat this issue, mathematics classrooms are transforming from traditional paper and pencil learning to more student-centered learning through the integration of technology. Technology can provide teachers with more opportunities to help reinforce prior knowledge that is needed to complete more complex mathematics tasks while simultaneously challenging advanced students.

Technology is now a part of everyday life, and with the implementation of the International Society for Technology in Education (ISTE), technology is also a part of education (Vucaj, 2020). ISTE is composed of a community of global educators who create guidance, professional development, networking opportunities, and events as well as the ISTE Standards to encourage the development of solutions and connections that benefit all students to be prepared to succeed in an ever-changing technological environment.

The ISTE Standards provide worldwide guidance for educators and schools to integrate technology into the curriculum. These standards are well established with a history of over twenty years and are adopted in all fifty states throughout the United States. They are continuously updated to “reflect the latest research-based best practices that define success in technology to learn, teach, lead and coach” (“The ISTE Standards”, 2021). The technical skills and standards are not only applied in computer classes but throughout all subjects and in all grade levels. This has opened the door for educators in all subject areas to utilize technology and the ISTE Standards to intensify practice, promote collaboration with peers, challenge teachers to reassess traditional teaching methods, and prepare students to take charge of their education (“The ISTE Standards”, 2021).

When the COVID-19 pandemic began in the United States, schools were forced to close and offer some type of online or hybrid learning. This forced school districts and states to close the technology gap and offer more options for all students. Joseph South, the chief learning officer for ISTE, expressed concerns that with the sudden shift to online learning, school districts were operating in crisis mode, which would set low expectations for online learning. However, he, along with the rest of the team at ISTE, viewed the COVID-19 pandemic as an opportunity to revamp the educational system by increasing technology in the classroom “to enhance learning and also build resiliency” (Krueger & Snelling, 2020). Instead of viewing technology as a last-minute intervention due to the COVID-19 pandemic, South hopes that educational leaders will embrace technology within education to ensure quality learning, whether online or in-person (Krueger & Snelling, 2020).

At the beginning of the pandemic, in April of 2020, the US Census Bureau partnered with five statistical agencies to collect data in regard to the COVID-19 pandemic. Part of their data collection focused on technology for school-aged children. It was found that fourteen percent of children did not have internet access at home, which equates to approximately nine million students across the United States. Seventeen percent of children did not have access to a laptop or desktop computer at home, which is approximately eleven million students (USAFacts, 2020). This demonstrates a lack of equity among students within the United States. Students who do not have internet access or a laptop/computer are referred to as underserved students because they do not have the same educational opportunities as their peers ("Equity in Education", 2021). The opportunity gap for these students demonstrates the need for equity in education to ensure that disadvantaged students are given the same opportunities as their peers.

Many states and educational agencies have tried to close this technology gap by giving all students access to online or hybrid learning. For example, on March 10, 2021, the governor of New Jersey, Phil Murphy, announced that every student in New Jersey now has access to a laptop as well as internet access (Clark, 2021). This announcement came almost one year after the COVID-19 pandemic forced a shutdown of all New Jersey schools. Similarly, Mississippi schools ordered 325,000 laptops or tablets to ensure that every student in public schools was given a device (Pettus, 2020). This was made possible by money that was allocated by the federal government due to the COVID-19 pandemic. The infrastructure for internet connection, particularly in rural areas, was also expanded to provide adequate internet access to all students throughout the state of Mississippi (Pettus, 2020). These are just two examples of how technology continues to transform the educational system. Students are now able to have a more equitable education with equal access to different types of resources. Specifically, students now have access to technology that can broaden their experiences with technology inside and outside of the classroom, such as incorporating digital game-based learning (DGBL) into education to give all students access to its unique features.

Digital game-based learning (DGBL) has unique factors such as customization, personalization, leaderboards, rewards, etc. that can engage students in the learning process throughout all subject areas (Ke et al., 2016; Hsieh et al., 2015). Student engagement is a key component to educational success, and with the integration of DGBL, engagement and academic achievement may be increased. Incorporating DGBL into the mathematics curriculum has been shown to bridge the gap in learning, differentiate instruction, and engage students (Yang et al., 2018; Hulse et al., 2019; Chen et al., 2012; Naik, 2017).

Background of the Study

Games have been a part of our lives for centuries, and since 1958, when the first video game was created, games have continued to evolve by incorporating more technology. With the rapid advancement and the general public appeal, it only makes sense with the ISTE Standards that technology plays an integral role in education within the United States. In the classroom, traditional games and teacher-centered learning are being replaced by digital tools and student-led learning, with educators being easily able to modify and differentiate content, which gives the students and the instructor greater control over learning.

DGBL is an autonomous tool that allows students to work independently, with certain classmates based on their learning requirements, or even with peers throughout the world. However, most mathematics curricula still follow a one-size-fits-all paradigm with limited distinction for pupils of lower and higher ability.

DGBL may alleviate some of the challenges that teachers face with differentiation and academic performance, but it may also alleviate some engagement challenges by providing a more engaging and motivating environment for students. Students' perceptions and opinions are often overlooked and undervalued when it comes to their education. Very rarely do students have a say in what they learn and how they learn, which can contribute to disengagement. Some students may excel in a subject, but become bored very easily when they are not challenged or intrigued with the lessons. On the other hand, some students may become easily distracted because the content is too advanced for their current ability. DGBL can serve to address these limitations and even provide students and teachers with immediate feedback.

It has been shown that digital games can give students a learning environment that encourages them to practice their abilities while also delivering positive and timely feedback while keeping their attention (Denham, 2019). In an educational setting, a well-designed game may serve various objectives, such as giving assessment data to the teacher while engaging students in the learning process, as well as giving feedback to students to assist them in better guiding their learning process (Groff, 2018). This can provide teachers in all content areas with immediate and consistent feedback, allowing them to differentiate and remediate education so that all students can achieve their full potential.

Incorporating digital games into the mathematics curriculum is one method to close the learning gap, diversify instruction, and keep students engaged (Gil-Domenech & Berbegal-Mirabent, 2019). Teachers may now use DGBL to take a new approach to teaching and learning by merging technology and education that is tailored to specific academic goals, making learning more accessible to everyone, everywhere. More recently, the educational system has embraced technology, and DGBL has begun to emerge as a prominent topic in educational research.

Statement of the Problem

This study involved sixth, seventh, and eighth-grade students and examined how students' prior engagement was related to their academic achievement as well as investigated students' motivation while utilizing DGBL in mathematics based on their autonomy, competence, and relatedness. Several variables, such as grade level, placement in mathematics class, academic challenge, learning with peers, experiences with faculty, campus environment, autonomy, relatedness, and competence were investigated.

Mathematics educators are responsible for enhancing academic achievement to comply with and possibly surpass state requirements. Educators must use best practices to meet or exceed these standards, which means that educators need to be inventive to attain this objective (Davis, 2017). The emphasis in the classroom has shifted to include both conceptual comprehension and computational or procedural proficiency (Davis, 2017). Considering these demands on educators, DGBL may be utilized to integrate new and innovative practices. This study helped the researcher assess whether DGBL has the potential to increase students' mathematics academic achievement as well as examined how students' prior engagement impacted students' mathematical achievement. This study also investigated students' motivation for using DGBL in a middle school mathematics setting to determine the relationship between motivation, academic achievement, and prior engagement. The current research on DGBL is abundant, but several limitations were identified.

Most of the current studies on DGBL were conducted in countries outside of the United States, such as Taiwan, the Netherlands, Australia, Spain, etc. An abundant amount of research on different aspects of DGBL took place in Taiwan (Chen & Hwang, 2017; Chen & Law, 2016; Chen et al., 2019; Chen et al., 2018; Chen et al., 2016; Chen et al., 2015; Chen et al., 2012; Chen, Liao et al., 2012; Chen et al., 2019; Hsieh et al., 2015; Hsu et al., 2017; Ku et al., 2016; Shihl & Hsu, 2016; Wang, 2020; Yang et al., 2017; Yang et al., 2018). There were many fewer peer-reviewed articles with studies conducted within the United States. The current study took place within the United States, so it helped fulfill the need for more research on these demographics. More research also needs to be completed by various researchers within the United States. Specifically, more research needs to be conducted using different research methods within mathematics DGBL involving middle school participants.

Based on the current research, there were no studies found that have shown that DGBL could hinder academic achievement in mathematics. However, there have been studies that have shown there is no difference in academic achievement when using DGBL as opposed to traditional teaching methods (Watson-Huggins & Trotman, 2019;

Hulse et al., 2019; Carr, 2012). These studies showed that academic achievement remained the same or increased with the implementation of DGBL.

Academic achievement may be enhanced by using DGBL since it provides a platform for students to have a demanding, yet engaging experience, motivating them to persevere through challenges and flourish (Chen et al., 2016). DGBL is unique in that it may boost students' intrinsic and extrinsic motivation, which can motivate them to keep using it which can then increase their academic achievement (Baek & Touati, 2017; Shihl & Hsu, 2016). It was discovered that DGBL encourages student learning, motivates learners, and improves the learning experience (Naik, 2017). It has also been shown that while participating in DGBL student engagement may also be increased which can have a positive effect on in-game performance (Chen, Law, and Huang, 2019; Ke et al., 2016; Hamari et al. 2016). This demonstrates the need for more research to find out if DGBL has a positive effect on academic mathematics achievement or if there is no effect on academic achievement. As well as investigate the relationship between academic achievement, engagement, and motivation.

Theoretical Framework

The self-determination theory (SDT) is composed of several mini-theories which were created to explain motivationally based occurrences. It has three main elements, autonomy, competence, and relatedness, which create a supportive environment for people to pursue their passions and take on new challenges (Ryan & Deci, 2002). This theory informs this study since DGBL can satisfy all of these innate needs (Ryan et al., 2006).

Digital games offer an unmatched capacity to build autonomous conditions, especially within education. In an educational setting, an autonomy-supportive environment is one in which educators consider students' interests and perspectives and provide timely feedback and opportunities for student choice and self-initiation (Ryan & Deci, 2002). DGBL can give students choice, allow for rewards, and provide prompt feedback, which can increase autonomy, student engagement, and personal value (Ryan et al., 2006). Teachers who support autonomy boost intrinsic motivation and internalizations while also appearing less demanding (Reeve, 2002). Within DGBL when there are flexible rules and a large range of options available throughout the game, autonomy is achieved (Rogers, 2017).

Competence is not a skill that can be achieved, but it is a sense of self-assurance and effectiveness in action as a result of the desire and perseverance to conquer barriers and challenges in order to improve one's own abilities (Ryan & Deci, 2002). Since competence is an innate need to overcome hurdles and challenges to improve one's abilities, it can be improved through the use of DGBL by giving students access to challenges, positive feedback, and rewards. A player must believe that the objectives they are seeking to achieve are attainable through different levels of the game. For example, the game may provide bonuses, challenges, and opportunities to unlock new areas of the game.

Relatedness refers to the natural need to feel linked to others and to have a sense of belonging, which can enhance motivation (Ryan & Deci, 2002). Relatedness can be met when DGBL involves characters, a plot, or any community-building activity such as peer-to-peer communication (Rogers, 2017). Different DGBL platforms allow for different interactions amongst players, such as multiplayer games and single player games. Multiplayer games were found to provide the most opportunities for interactions between players, which satisfied the psychological need for relatedness (Ryan et al., 2006).

The SDT can help define the motivational factors, based on autonomy, competence, and relatedness, for using DGBL. This study examined the motivational factors of students after using the DGBL intervention, as well as investigate students' prior engagement and academic achievement. This explanatory sequential mixed methods study collected quantitative and qualitative data from middle school mathematics participants.

Purpose of the Study

The primary purpose of this explanatory sequential mixed methods study was to determine if students' prior engagement was related to their academic achievement as well as to investigate students' motivation while utilizing DGBL in mathematics based on their autonomy, competence, and relatedness. Since this was a mixed methods study, both qualitative and quantitative data was collected and integrated into the study. By collecting qualitative and quantitative data, there was "more dimension to the analysis and findings" of the study (Miles et al., 2020, p. 36).

Following the explanatory sequential mixed methods design, the data collection took place over the course of ten weeks. Middle school students voluntarily participated in an after-school DGBL mathematics club. Before the intervention, the students completed a quantitative pretest (Appendices A, B, and C) and the quantitative modified NSSE survey (Appendix D). The students began utilizing the DGBL program Prodigy.

Prodigy is a digital mathematics game set in a fantasy wizard world that is adaptive and self-paced. The program was used for one hour every week during the after-school club. Following the intervention, the students completed the quantitative mathematics posttest. After the quantitative data was collected, the qualitative motivational survey was administered.

Mathematics educators are expected to increase students' academic performance to meet or exceed state standards. To achieve this goal for all learners, educators need to be innovative in the way that they deliver instruction to students. This study helped researchers determine if DGBL is an effective tool that can be used in middle school mathematics classrooms. The students first completed a quantitative mathematics pretest to determine their current academic level. The researcher designed the pretest by following the state mathematics standards and using the Big Ideas Learning Mathematics curriculum. Each grade level had its own pretest, which consisted of fifteen questions. Students were compared across groups to determine if students in particular groups performed better on the posttest as compared to the pretest (Appendices A, B, and C). For example, the researcher looked at different characteristics such as the students' grade level and the students' placement in their mathematics class (on grade level class or above grade level class).

Based on previous research, was assumed that DGBL would maintain or improve students' academic achievement in mathematics. However, this study took that one step further to help specify if certain groups of students benefit more from utilizing DGBL. Based on the modified NSSE questionnaire (Appendix D), the researcher was able to determine if specific groups of students or students with specific characteristics, as identified by the modified NSSE questionnaire, had stronger academic performance while utilizing DGBL. There are four main engagement themes that were identified within the modified NSSE: academic challenge, learning with peers, experiences with faculty, and campus environment.

During the open-ended survey (Appendix E) that students took at the conclusion of the intervention, the researcher was able to determine the students' motivation based on their autonomy, competence, and relatedness. The researcher was then able to combine the data to determine the relationship between students' engagement, identified from the modified NSSE survey, academic achievement, identified from the pretest and posttest, and their motivation, identified through the open-ended survey developed utilizing the SDT.

Research Questions

DGBL can be used independently by students, which can allow the teacher to work with specific students or groups of students based on their learning needs. Most mathematics textbooks still follow a "one size fits all" model with minimal differentiation for below grade level and above grade level students.

Specifically, this study investigated:

1. How does utilizing DGBL within mathematics affect students' academic achievement in 6th, 7th, and 8th grades?
2. Is there a relationship between students' prior engagement and their academic achievement after utilizing DGBL in a middle school mathematics setting?

3. How does the students' motivation, based on autonomy, competence, and relatedness, help explain students' academic achievement and engagement with the use of DGBL?

Assumptions of the study

Prior to the start of the study, informed consent was received from the parents/guardians of the students. It was stressed that the students who participated in the study remained anonymous throughout the data collection process. It was also noted that neither the students nor the parents were going to be compensated in any way for participating in the study, so participation was completely voluntary with no monetary incentive. It was assumed that the students were going to participate in the study from start to finish, but the students or parents had the option to opt-out at any time.

Due to the anonymity of the study, it was assumed that the students who participated in this study answered questions from the closed-ended modified NSSE survey and the open-ended survey honestly. It was also assumed that students completed the pretest and posttest to the best of their ability. The students' names and any identifiable information remained anonymous throughout the study, so it was assumed that students gave honest responses.

Definition of Terms

Digital Game-Based Learning (DGBL) refers to activities with electronic games at their center, either as the main activity or as a stimulant for other connected activities, with learning as a desirable deliberate consequence (Kirkland et al., 2010).

Engagement is the amount of time and effort students devote to their studies and other educationally beneficial activities, as well as how the institution allocates resources and organizes the curriculum and other learning opportunities to encourage students to participate in activities (“National Survey of Student Engagement”, 2021).

Academic Achievement refers to how well students succeed in the intellectual disciplines they are taught in school (York et al., 2015).

Motivation is what moves people to act or move others to act (Ryan & Deci, 2002).

Autonomy involves a person’s self-interests and values (Ryan & Deci, 2002).

Competence is a feeling of assurance and effectiveness in action that comes from the desire and perseverance to overcome barriers and challenges in order to improve one's own abilities (Ryan & Deci, 2002).

Relatedness is a natural need to feel connected to people and the community and to have a sense of belonging (Ryan & Deci, 2002).

Chapter 1 Summary

K-12 educators in the United States are constantly trying to meet or exceed the academic standards that are set forth by the Department of Education, with student academic achievement at the forefront of these standards. Specifically, mathematics teachers are responsible for following state and federal standards to achieve academic success on standardized tests. Educators must be inventive in the manner in which they provide instruction to students to attain this goal for all learners.

The main objective of this study was to examine how engagement impacts students’ mathematical academic success while using DGBL. This study will also examined the students’ motivation for using DGBL in a middle school mathematics setting. This explanatory sequential mixed methods study will collected quantitative data followed by qualitative data. During phase one of the study, the researcher collected quantitative data from the questionnaire as well as a pretest and posttest. During phase two of the study, the researcher collected qualitative data from an open-ended survey.

The following chapter will provide a detailed literature review outlining the current body of research on DGBL. This research provided the foundation for the current study.

CHAPTER TWO: LITERATURE REVIEW

Introduction

This chapter provides a detailed literature review to provide an overview of previous published research on DGBL. More specifically, this research guided this study to help determine the effectiveness of DGBL on middle school students' academic achievement in mathematics, how student engagement can affect academic achievement, and the relationship between students' motivation, based on competence, autonomy, and relatedness, for DGBL and student academic achievement. DGBL has been studied extensively, however, this current research integrated the self-determination theory, middle school students, and mathematics to create a unique study focused on engagement, academic achievement, and student motivation.

The following literature review outlined current research and theories aligned to this study. Specifically, this chapter is organized into four main sections: (a) digitalization of K-12 education, (b) self-determination theory and DGBL, (c) effectiveness of DGBL, and (d) design elements of DGBL.

Digitalization of K-12 Education

Games have been an integral part of people's lives for centuries. Throughout that time, some games have evolved to incorporate technology. Video games have shown huge advancements in recent years and continuously develop better graphics and content. Although the average age of people who purchase video games is in their late twenties, the majority of video game players are both men and women who are teens or young adults (Hutchison, 2007). Video games are just one way of integrating games and technology and these statistics emphasize the attractiveness of video games to people of all ages, but especially to young people.

Kirkland et al. (2010) defined DGBL as “activities that have game at their core, either as the main activity or as a stimulus for other related activities and have learning as a desired intentional outcome” (p. 4). For years now, the educational system has embraced technology, but more recently DGBL has become a forefront of educational research. In the classroom, traditional games and teacher-centered learning are being replaced by digital tools and student-led learning. Educators can tailor content with the push of a button, giving the students and the instructor greater control over learning. There is a level of customization and personalization available for the teacher and the student that was impossible without technology, which provides learning opportunities that are easily adapted to each student to create a truly differentiated classroom.

DGBL has even been shown to increase prefrontal brain activation which can indicate a stronger emotional appeal and engagement as well as the ability of DGBL to attract the attention of the participants as opposed to non-game-based learning (Kober et al., 2020). Digital games can provide students with a learning environment that can motivate them to practice their skills, while providing positive and fast feedback and maintaining their interest (Denham, 2019). A well-designed game can serve multiple purposes in an educational setting, such as providing assessment data to the teacher while engaging students in the learning experience. It can also provide feedback to the students to help guide their learning process more efficiently (Groff, 2018). This can give the teachers quick and consistent feedback in order to differentiate and remediate instruction to allow all students to reach their full potential.

Incorporating digital games into the mathematics curriculum is a great way to bridge the gap in learning, differentiate instruction, and engage students (Gil-Domenech & Berbegal-Mirabent, 2019). Through technology, teachers are now able to take a personalized and multifaceted approach to instruction, with the option of using self-created DGBL tools or integrating pre-made DGBL tools. Digital game-based learning differentiates itself from standard teaching practices as it can take place in a formal setting such as a classroom, or an informal setting such as in a student's home. Today, with DGBL teachers can take a unique approach to teaching and learning by incorporating technology and education designed with specific academic goals to make learning more accessible to everyone, everywhere.

Self-Determination Theory and DGBL

The self-determination theory (SDT) is a macro-theory composed of several mini-theories which encompass human conduct of all kinds in all areas to constitute SDT (Ryan & Deci, 2002). Initially, SDT was composed of four mini-theories: cognitive evaluation theory, organismic integration theory, causality orientations theory, and basic needs theory (Ryan & Deci, 2002). Each of these mini-theories was developed to describe motivationally based occurrences. SDT has since been expanded to include two additional mini-theories: goal contents theory and relationships motivation theory. These theories have been "developed and refined through empirical investigation across different domains, cultures, and demographics" (Olafsen et al., 2018, p. 179).

The theory has three main components: competence, relatedness, and autonomy. According to Ryan and Deci (2002), competence is not an achievable skill, but rather a "sense of confidence and effectance in action" due to the desire and persistence to overcome obstacles and challenges to enhance one's own skills (p. 7). Relatedness refers to the innate need to be connected with others with a sense of community and togetherness. Within the SDT, autonomy involves self-interests and values. As displayed in Figure 1, together these three needs provide a supportive environment for people to develop their interests, seek challenges, "discover new perspectives, and to actively internalize and transform cultural practices" (Ryan & Deci, 2002, p. 3).

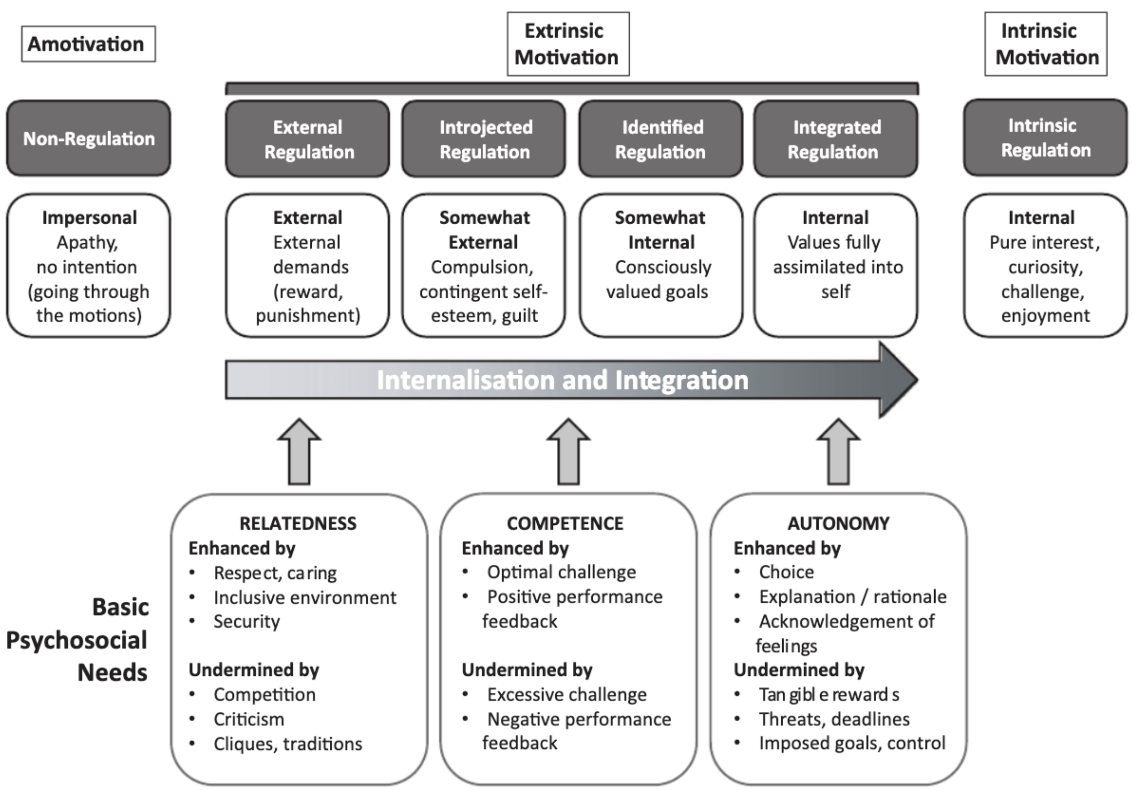

Figure 1 Adapted from Ryan & Deci's SDT (Cook & Artino, 2016, p. 1010).

One aspect of SDT that separates itself from other theories is the acceptance of different types of extrinsic motivational factors (Olafsen et al., 2018). Someone can be intrinsically motivated, meaning that they “engage in the activity because they find it interesting or enjoyable”, or someone can be extrinsically motivated, meaning that they are motivated by an outside source (Olafsen et al., 2018, p. 179). The extrinsic motivation can be a reward, or it could also be to avoid a punishment, both of which are acknowledged with SDT. Figure 2 shows the SDT continuum with types of motivation and regulation.

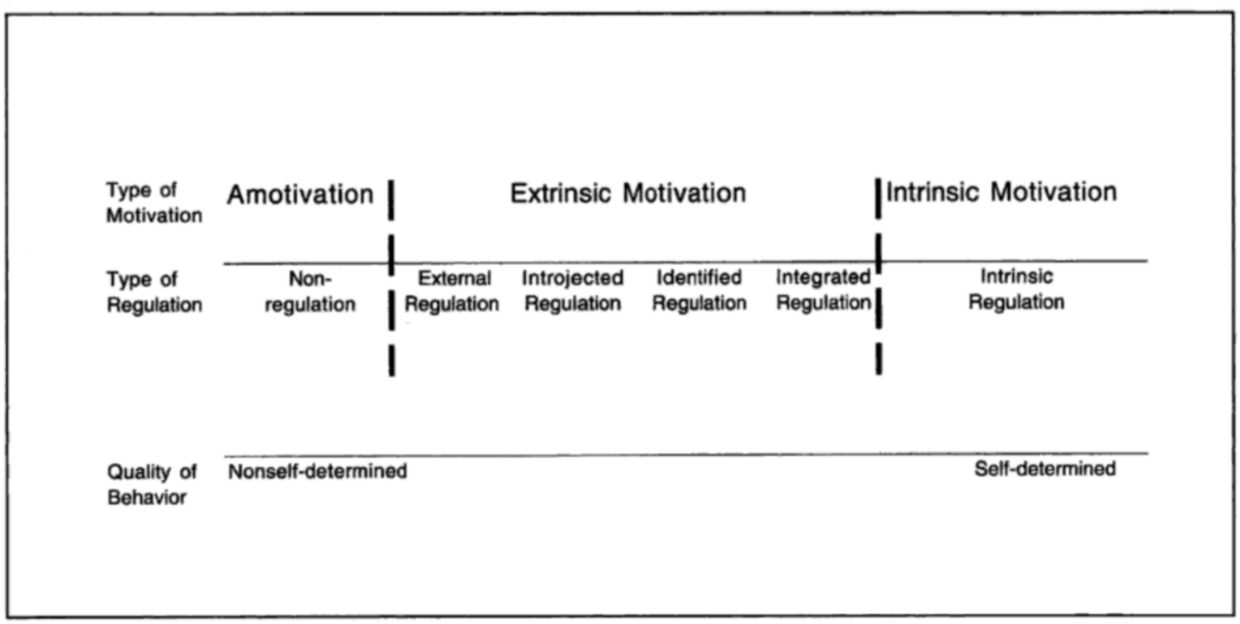

Figure 2 Self-determination theory continuum (Ryan & Deci, 2002, p. 16).

An autonomy-supportive environment, specifically in an educational setting, is one in which educators take into account the students’ interests and perspectives and “allow opportunities for self-initiation and choice, provide a meaningful rationale if choice is constrained, refrain from the use of pressures and contingencies to motivate behavior, and provide timely positive feedback” (Vansteenkiste et al., 2006, p. 21).

Autonomy-supportive teachers promote intrinsic motivation, internalizations, and appear less demanding and pressuring (Reeve, 2002). Teachers who support autonomy rather than try to control students' behaviors are part of the reason for student success. Autonomously motivated students "thrive in educational settings" by demonstrating high academic achievement, overall enjoyment of school, a preference for challenges, and are creative (Reeve, 2002, p. 183).

Digital games have the unrivaled ability to create an autonomous environment. According to Ryan et al. (2006), autonomy can be increased in digital games when there is choice, rewards, and open directions. This seems to improve the interest and perceived personal value which increases the participant's autonomy. Game designs that have a lot of flexibility and choice, as well as rewards and feedback within the game, provide increased autonomy for players. Autonomy was achieved when there were flexible rules and a wide range of actions throughout the game. Interestingly, feedback was found to reduce autonomy if it was too prominent throughout the game so having a balanced amount of feedback was key (Rogers, 2017).

A large part of SDT discusses satisfying people's basic needs to fulfill their higher-level needs. Watson-Huggins and Trotman (2019) found that if a player's basic gaming needs within a mathematics classroom are not met, they are unlikely to continue gaming at a higher level. However, if their basic needs are met, they are more likely to continue gaming at a higher, more complex level. SDT researchers take this social context and explore how these qualities help promote autonomous motivation. Vansteenkiste et al. (2006) stated that if the social context is more autonomy-supportive the more "it maintains or enhances intrinsic motivation and the more it facilitates the internalization and integration of extrinsic motivation" which can then promote adaptive learning outcomes (p. 22).

Competence or perceived competence can amplify when there are continuous challenges and opportunities for players to receive positive feedback and rewards. Relatedness was satisfied when a digital game included characters and a story (Rogers, 2017). Games can produce feelings of autonomy, competence, and relatedness (Ryan et al., 2006). When a game had a positive influence on competence and relatedness, it led to greater enjoyment of the game (Rogers, 2017). Competence and autonomy can help increase motivation and enjoyment within gaming which in turn can increase engagement as well as increase inclination for future game play (Ryan et al., 2006).

Engagement is a valuable aspect of education and "is a useful concept for applying self-determination theory to educational settings" because teachers can use observable evidence of student motivation (Reeve, 2002, p. 194). Teachers are able to gather information and data on engagement that they can identify and monitor. The way that the teacher moderates engagement "becomes a question of how they create classroom conditions to support and nurture students' needs for self-determination, competence, and relatedness" (Reeve, 2002, p. 194).

Effectiveness of DGBL

Academic achievement is one of the key goals in the K-12 educational system within the United States. The U.S. Department of Education's mission "is to promote student achievement" as well as prepare students for "global competitiveness" (U.S. Department of Education, 2021). Educators are constantly trying to meet or exceed the academic standards and curriculum that are set by school districts and states. In K-12 education, educators are bombarded with standardized tests to provide proof of academic achievement. Most states even evaluate a teacher's effectiveness based on standardized test results to show whether the students showed growth throughout the year as well as from year to year. With so much emphasis on academic achievement in the K-12 school systems, educators need to find innovative and effective ways to reach all learners to improve students' academic achievement.

Mathematics is a core subject that all students are required to learn within K-12 education in the United States. Over several decades, states and agencies have worked together to address mathematics learning within K-12 school districts. In 2010, almost all states within the United States, with the exception of seven states, adopted the Common Core State Standards for Mathematics (CCSSM). This was an opportunity to give all students equal opportunity and consistency by having nationally based standards. It also gave the government and educational departments more opportunities for collaboration as well as standardization (Dossey et al., 2016). It was developed from "the best state standards, international curricular frameworks, and research results concerning mathematics teaching and learning, as well as teachers' experiences" (Dossey et al., 2016, p. 19). The main goal of implementing the CCSSM throughout the nation was to improve the educational system to ensure that high school graduates are college and career ready in mathematics. (Dossey et al., 2016).

In 2021, there were still several states who utilized the CCSSM, however many states have modified the standards to fit their individual needs. Currently states such as Arizona and Oklahoma have developed their own standards, while states such as New York, New Jersey, and Georgia have developed their own standards based on the

CCSSM. Based on the feedback of various stakeholders, such as parents, teachers, school districts, etc., it was determined that the CCSSM attempted to be a one-size-fits-all which did not suit the needs of the individual states (McKneely, 2020).

Digital game-based learning has the potential to engage students in academic learning and attract the attention of the students while increasing the students' complex problem-solving performance (Hung et al., 2014; Eseryel et al., 2014). Ke et al. (2016) defined learning engagement as "a collection of mindfully goal-directed behaviors and reflections demonstrated to indicate a meaningful and deep involvement in learning activities" (p. 1183). DGBL can captivate students in active learning by increasing their levels of engagement (Hamari et al., 2016). DGBL can stimulate students' sense of enjoyment and satisfaction which then has an effect on other behaviors such as motivation and persistence in learning (Baek & Touati, 2017). These are key factors for students to remain engaged in the game as well as in the academic learning process.

Academic Achievement

In the classroom, academic achievement can be measured in multiple ways, such as through assessments, observations, projects, and reports. DGBL can increase academic achievement and enhance learning outcomes all while giving teachers data to support student growth and learning (Hung et al., 2014; Baek & Touati, 2017; Turgut & Temur, 2017; Kao et al., 2017). DGBL makes learning more meaningful and tangible for students by allowing the students to find connections between prior knowledge and experiences and new knowledge and experiences (Kao et al., 2017). These connections can help bridge the learning gap to increase academic achievement. Learning performance can be improved through the use of DGBL because it provides a platform for students to have a challenging, yet enjoyable experience which can motivate the students to continue to persevere through problems to increase growth (Chen et al., 2016).

Kober et al. (2020) found that when students completed a task during a game-based version as compared to a non-game-based version, the students made fewer errors. Similarly, Siew (2018) found that DGBL is more effective in increasing students' performance in mathematics learning as opposed to traditional instruction for elementary-aged students. It was even found that students experienced more joy and found the game-based version "more attractive, novel, and stimulating" (Kober et al., 2020, p. 13). Baek and Touati (2017) determined that there was a direct relationship between enjoyment and academic achievement. The more the students enjoyed a game, the higher the game achievement, which would in turn have a positive effect on academic achievement. Strides can be made to master various levels until goals are met and the individual is ready to move on to a new activity or topic.

DGBL can increase students' intrinsic motivation, which can then increase levels of enjoyment within the game (Baek & Touati, 2017). In regard to intrinsic motivation Shihl and Hsu (2016) identified four key themes while utilizing DGBL: reflection, creative thinking, accepting frustrations and failures, and confidence (p. 186). All of these factors contributed to the students' having increased academic achievement. In regard to extrinsic motivation, three themes were identified to have a positive effect on academic achievement: leadership, cooperation, and activeness (Shihl & Hsu, 2016, p. 184). DGBL is unique because it can increase students' intrinsic and extrinsic motivation which can encourage students to continue to use DGBL, which will then increase academic achievement.

Traditional teaching is usually teacher-centered with a lot of direct instruction. However, DGBL can make learning more student-centered which leaves room for discovery, differentiation, and creativity for each student. Instruction through games has been shown to promote “learning outcomes" better than traditional instruction (Hung et al., 2014, p. 161). If students are more stimulated by and attracted to DGBL, there is more opportunity for increased academic achievement (Hung et al., 2014). Since DGBL can easily provide differentiation for students, it can scaffold the learning for the lower-achieving students to bridge the achievement gap and increase students' learning achievement as well as provide challenges for high-achieving students (Yang et al., 2018). Chen and Hwang (2017) found that DGBL was able to bridge the gap between low-achieving students and high-achieving students. The low-achieving students particularly benefited from implementing a “team competition-based gaming approach into ubiquitous learning activities" (p. 95). Students can enhance their communication and problem-solving skills while using DGBL and even improve teamwork and group goals (Shihl & Hsu, 2016).

DGBL is also able to provide transparency for students, educators, and parents. With immediate feedback, students can self-access and improve their learning experience, educators can receive detailed reports, and parents can monitor progress. Teachers can implement DGBL within the classroom, but the excitement and joy may inspire students to work independently at home as well. Parents report that DGBL has given them the opportunity to “support their child’s learning” and have “affirmative and formative feedback” (Holmes, 2011, p. 13). Parents can see their child’s strengths and weaknesses, which may help support the academic growth of the student. DGBL can easily be incorporated into a child's home life which will help strengthen the relationship between the child and the parent as well as the parent and the teacher. Parents can be more involved in the educational process and advocate for their children when they see a disconnect with academic achievement.

DGBL within Mathematics

When the new Common Core State Standards for Mathematics (CCSSM) were introduced to teachers, they needed to use best practices to meet/exceed the standards (Davis, 2017). Now that most states have modified these standards or developed their own, the focus of all standards are centered on a deep knowledge and understanding of mathematics and are focused on having students apply concepts instead of just memorizing formulas and operations. Classroom instruction was changed to emphasize "both conceptual understanding as well as computational/procedural fluency" (Davis et al., 2017, p. 247). Teachers needed to analyze their current teaching styles and integrate new and innovative practices, such as DGBL.

When researching the integration of DGBL, specifically within mathematics, there was a noticeable difference in the way that it was studied. Several studies related specifically to infusing digital game-based learning into mathematics class used experimental and control groups to compare their results (Yang et al., 2018; Watson-Huggins & Trotman, 2019; Ke, 2019; Vandercruysse et al., 2017; Hulse et al., 2019; Chen, Liao, et al., 2012; Carr, 2012). One possible reason for this could be accessibility. Most of these studies compared different classes in the same school or different classes within different schools. Another possible reason for this is because the researchers wanted to compare the differences that DGBL had on certain aspects of learning such as academic achievement, motivation, or engagement as opposed to traditional-based teaching.

Ke (2019) completed a study with sixth-grade mathematics students, but this study was focused only on problem-solving. The experimental group that was exposed to DGBL scored significantly better than the control group on the problem-solving posttest. Yang et al. (2018) had a similar finding by comparing the students who were using DGBL with a progressive prompting strategy as opposed to traditional DGBL without the prompting strategy. Using progressive prompting allowed for hints and guidance throughout the DGBL. It was found that the students with the prompting strategy had "superior learning performance" (Yang et al., 2018, p. 328). Integrating prompting within DGBL could also be helpful to encourage students to read all of the questions and problems thoroughly. It was found that students often do not read or skim task narratives and directions, which could lead to incorrect responses (Ke, 2019; Ke et al., 2016). Allowing the students to have access to progressive prompts as well as active investigations gives students more opportunities to successfully complete mathematics DGBL tasks.

When comparing intrinsically and extrinsically DGBL environments in mathematics, it was found that extrinsically integrated games improved students' academic achievement, motivation, and perceived usefulness (Vandercruysse et al., 2017). In the extrinsic game, the mathematics content was not integrated directly into the game as opposed to having the mathematics content directly integrated into the games' story and mechanics. All students improved pretest to posttest but students who completed the extrinsic version of the game showed significant improvement in academic achievement. Naik (2017) investigated incorporating game-based learning in higher education mathematics classes. It revealed that game-based learning supports student learning, motivates learners, and enhances the quality of the learning experience. More specifically, the researcher identified that students preferred games with higher levels of social interactivity.

Siew (2018) found that DGBL has a positive effect on elementary students' mathematics academic performance as opposed to traditional teaching and learning. However, Watson-Huggins and Trotman (2019) completed a study comparing DGBL and traditional teaching in a sixth-grade mathematics classroom and found that there was not a statistically significant difference between the academic performance of the control and experimental groups. It was shown that both groups performed well on the mathematics assessments. Likewise, Carr (2012) investigated the implementation of iPads within fifth-grade mathematics classrooms to incorporate DGBL. When comparing the experimental and control groups, it was found that iPad usage did not affect mathematics academic achievement. Both groups showed similar gains in post-test scores after the six-and-a-half-week study. It could be argued that DGBL has the potential to maintain proficiency and possibly increase academic achievement. Another reason for the difference in the results could be the age group that was used in the study. Elementary students are more likely to use games within the classroom as compared to middle school students (Siew, 2018).

Hulse et al. (2019) developed a study using a DGBL program that was originally intended for middle school students but was then adapted for elementary students. To take it one step further, the program was then converted into a gamified version and a non-gamified version. After comparing the pretest and posttest, there was no difference in the academic achievement of the elementary mathematics students between the gamified and non-gamified versions. However, when analyzing the student interaction and progression through the game, students who used the gamified version performed significantly better than the students using the non-gamified version. Even though there was no significant difference in regard to academic achievement, elementary students utilizing the gamified version were more immersed and engaged in the learning process.

In a similar study, Chen, Liao et al. (2012) studied elementary students using a DGBL quest. There were two versions of the game: one with quests and one without quests. Students who completed the quest version of the mathematics game performed higher in enjoyment, goal orientation, and goal intensity. The integration of quests "involved more expectations and satisfactions, which, in turn, affected students' perception of quest towards goal-pursuing" (Chen, Liao, et al., 2012, p. 324).

Incorporating DGBL into mathematics classrooms can help teachers transition from traditional paper and pencil lectures to more student-centered, cooperative learning environments (Gil-Domenech & Berbegal-Mirabent, 2019). There have been mixed reviews on the effect of DGBL on mathematics academic achievement, however, it has been shown to either maintain proficiency or improve academic achievement (Siew, 2018; Yang et al., 2018; Vandercruysee et al., 2017; Watson-Huggins & Trotman, 2019; Hulse et al., 2019, Carr, 2012). There have not been any studies that showed that incorporating DGBL into mathematics can hinder academic achievement. There are also several other positive effects of incorporating DGBL into a mathematics classroom such as increased engagement, motivation, enjoyment, student interactions, and progression through the learning material (Yang et al., 2018; Hulse et al., 2019; Chen et al., 2012; Naik, 2017).

Student Engagement

It has been shown that student engagement in DGBL had a significant effect on in-game performance (Chen, Law, and Huang, 2019). While participating in DGBL, players actively and deliberately plan out different strategies to successfully complete a task. This is especially true in more intricate quest-based games (Ke et al., 2016). Engagement can moderate the relationship between competition and in-game performance to optimize success (Chen, Law, Huang, 2019). By increasing the level of challenge and skill, students are able to achieve “higher degrees of engagement and immersion” (Hamari et al., 2016, p. 173).

Ronimus et al. (2019), reported that special education children who were more engaged and able to focus while using DGBL had a higher success rate within the game, which contributed to a higher level of academic success. This study focused on the reading fluency of second-grade special education students. Interestingly, the children’s self-reported engagement did not match with the adult-observed engagement. This may imply that younger children have a harder time self-identifying and reporting their engagement (Ronimus et al., 2019).

Hsieh et al. (2015) conducted a study using DGBL that focused on engagement. The students were recorded and engagement patterns, verbal and nonverbal, were coded. It was found that DGBL “can consistently increase students’ engagement” (p. 346). When the researcher analyzed the difference between the males and females, they found that male students tended to have continuous self-conversation while female students presented verbal and nonverbal behaviors when they were confused.

Similarly, Eseryel et al. (2014) completed a study where the high school participants played an educational game at least twice a week to analyze engagement. The engagement was measured by two main factors: the number of tasks completed, and the time spent on the game. There were several findings during this year-long study, however, the researchers focused a lot on game design. For example, it was found that to maintain student engagement during DGBL, it is imperative that “the individual tasks are not fragmented pieces of overall complex problem scenarios in the game narrative” (Eseryel et al., 2014, p. 50). DGBL can take on many different forms, but no matter what the storyline is, it is necessary to have a seamless integration of the educational content and the game design. The game design needs to be scaffolded in order to achieve optimal engagement and motivation throughout. DGBL can offer “optimal challenges, game-action-based, necessitated content processing, and gameplay relevance” that is necessary to actively engage students in the learning process (Ke et al., 2016, p. 1197). The authenticity of the game contents, such as the storyline, can help students have a more enjoyable experience while improving their knowledge and engagement (Yang et al., 2017).

It has been shown that student engagement can decrease during two phases of DGBL: during the directions and the feedback (Ke et al., 2016). Not reading the instructions led to students not being able to process the game rules. Similarly, Ke (2019) found that students spent an insufficient amount of time reading task narratives or problem statements. However, Wang (2020) found that when students were given step-by-step instructions with specific guidance, they were able to complete the DGBL at their own pace without their teachers' assistance. Directions are an important part of gaming, especially if it is a new game that is introduced to the students. The students need to be able to understand the specific directions before beginning the game or a new level.

The other aspect of DGBL where engagement seemed to decline according to Ke et al. (2016) was during the feedback section. When students would answer a question incorrectly, they would only spend "seconds reading the feedback screen" (p. 1191). This is problematic when it comes to comprehending the content because the feedback can offer guidance on how to correctly answer a question. DGBL can be very exciting and engaging for students, however, students need to be able to understand the directions and review the feedback to effectively complete the activity.

Collaborating with other players is another aspect that can encourage engagement among students. Collaboration involves students working together to complete a task (Chen et al., 2015). Students can use avatars, chat windows, or even collaborate within the classroom while using DGBL (Mikropoulos & Natsis, 2011). Collaboration allows for students to collectively hold discussions, use problem-solving techniques, and have social negotiations (Chen et al., 2015; Mikropoulos & Natsis, 2011). By having students work in groups, the teacher can create a student-centered environment where the students have "the chance to share knowledge, combine different capabilities, and discuss different points of view" (Gil-Domenech & Berbegal-Mirabent, 2019, p. 62).

Incorporating DGBL that has higher levels of social interactivity is preferred by students (Naik, 2017). By having these engaged interactions, students develop reflective practices that can be applied through other game-based learning, academic content, and real-world application (Mikropoulos & Natsis, 2011). Chen et al. (2017) stated that DGBL “improved students’ awareness of their collaboration and communication competences as well as their collective efficacy” (p. 95). According to Shihl and Hsu (2016) “knowledge is the result of social interaction and must be internalized to become integrated into personal schema” (p. 180). Group goals and personal goals are closely related, and one can have an effect on the other which in turn can affect engagement.

To optimize engagement, educators need to ensure that the students are grouped appropriately to help create the most effective learning groups. DGBL can engage students in collaborative learning which can help students build relationships as they struggle and eventually master the games and problems. It creates an environment that “can support authentic activities and encourage deeper discussion through collective problem solving” (Chen et al., 2015, p. 243-243). Working on problems in groups through digital games allows for students to see other people’s perspectives and share their skills to attain a mutual goal within the game (Danby et al., 2018). Group goals can be created and achieved through collaboration which can enhance students’ communication and problem-solving skills (Shihl & Hsu, 2016).

Design Elements of DGBL

The impact of digital game-based learning perceptions varies among students, teachers, and parents alike. The use of digital games can incorporate numerous features such as customization, personalization, competition, scaffolds, and rewards. Engaging students’ interest is only one component that can be used to evaluate the effectiveness of learning. There has been a lot of debate regarding which features are the most beneficial and which features may hinder the learning process (Chen, Law, & Huang, 2019; Chen et al., 2018; Chen, Chou, et al., 2012; Chen et al., 2015; Vandercruysse et al., 2013; Chen, 2018; Admiraal et al., 2011; Gil-Domenech & Berbegal-Mirabent, 2019).

Students with varying needs, interests, and abilities are engaged in DGBL because the instruction is able to be individualized for students. Games can be built to meet various needs and desires and educators need to be aware that “there is a need to accommodate the preferences” of the students (Ku et al., 2016, p. 367). The use of interactive games in education is a vital way of encouraging and motivating all learners. Educators are more willing to incorporate digital games into the learning process because DGBL has been shown to have positive effects on academic performance, satisfaction, motivation, attitude, and engagement (Turgut & Temur, 2017).

It was found that not having many opportunities for choice could lead to lower satisfaction and engagement, which is why DGBL should be designed with flexibility that “can allow learners to modify the game settings” to their preferences (Ronimus et al., 2014; Ku et al., 2016, p. 367). DGBL needs to contain appropriate content while also “be flexible enough to be tailored to the needs of learners” (Yang et al., 2017, p. 897).

In education, rewards can take on many different forms, especially in the K-12 settings. Many elementary teachers have some type of “treasure box” that contains prizes for different students based on various behaviors or activities. Some middle school and high school teachers might have behavior management and reward systems in place such as giving out homework passes, giving the students free time, or allowing them to listen to music. Even as adults in the workforce, people look for positive reinforcement and evaluations from their boss or supervisor. Digital game-based learning can combine a lot of these rewards within the gaming system. The rewards within DGBL vary by game but can include options such as students earning badges, leveling up, and positive reinforcement.

Customization and Personalization

An aspect of digital game-based learning that can be intriguing for many students is personalization and customization. Personalization refers to students' ability to advance through the academic material at different rates based on their own needs, while customization is learning that is adjusted based on the preferences and interests of the learners (Basye, 2018). Not only can the content of the DGBL be customized to a students' ability level, but so can the characters and the virtual worlds. This can add a fun and individualized element to the learning experience. Ku et al. (2016) stated that customization and personalization were helpful in the learning experience and performance. Customization and personalization can also increase academic performance, retention, responsibility, collaboration, communication, and problem-solving (Vasileva et al., 2015). These transferable skills are not only applicable in the classroom, but also in real-world situations as well as in future careers. These skills can allow students to take charge of their learning process. Personalizing and adapting game-based learning encourages students to take an active part in their education by engaging the students and teaching them how to learn (Basye, 2018).

A large part of the personalization and customization within DGBL is the creation of avatars, the character within the game. Chen, Lu, and Lu (2019) studied eighty-two students, separated into two groups that used the same DGBL tool, but they were assigned two different versions. One group had the option of customizing the gender, appearance, profession, and animal of the avatar, while the other group had an avatar but could not change it. It was found that students benefited more from the customizable version of the digital game. Being able to customize the avatar gave the students the opportunity "to create detailed embodiments of their own preferences" which allowed the students to visualize themselves within the virtual world (p. 388).

Wang et al. (2018) specifically investigated the use of a game-based intervention for autistic students. Students were able to customize their avatars and use their avatars to communicate with other students in different situations, which is something that these students struggled with within the classroom and social settings due to having Asperger's Syndrome. With the use of the avatars, these students were able to have verbal and nonverbal interactions that were socially appropriate. These social interactions will "eventually lead to effective learning" (Wang et al., 2018, p. 754). By having students create their own avatars and use those avatars as a way of communicating, the game was able to "transform collaborative learning" and classroom-like tasks (Wang et al., 2018, p. 756).

Students come from different backgrounds and home lives and may have different levels of prior content knowledge, as well as different levels of technology skills. When implementing DGBL, all of these factors need to be taken into consideration. However, customization and personalization are able to not only balance the factors but also integrate student interests. DGBL can "accommodate the unique needs of learners" by providing a flexible learning environment (Yang et al., 2017, p. 897). Learning becomes individualized for all students by differentiating content and play. DGBL can personalize, customize, and refine academic material to encourage collaboration (Ku et al., 2016; Chen & Law, 2016).

Prior knowledge is an important concept in education. DGBL can help build upon prior knowledge and previously taught concepts. There needs to be long-term goals within education and DGBL because having no long-term goals or continued growth can lead to student dissatisfaction (Iten & Petko, 2016). The students need to have academic goals as well as goals within the game, such as reaching the next level or attaining a certain number of points. Digital games are able to not only allow the students to gain knowledge but also “offer a rich context that allows students to reinforce and consolidate their knowledge through practice” (Chen & Law, 2016, p. 1201).

<u>Competition</u>

With the use of DGBL, competition can take on many forms, such as competing against other players, a computer, time, or your own score. People are naturally competitive and DGBL can seek to enhance the drive for competition which will increase student involvement. There are currently mixed results about the true effect that competition has while being implemented in DGBL.

Two separate studies that evaluated game-based learning within middle school science classrooms found that competition was not beneficial to student learning (Chen, Law & Huang, 2019; Chen et al., 2018). In the first study, Chen, Law, and Huang (2019) focused on online science games which compared two groups of students. One group had access to a competition aspect of the game with a leader board and the other group played the same game but without a leader board. The students who were a part of the competition group with the leaderboard did not perform as well as the non-competition group. One explanation for this was that the students were not as focused on the content because they were too focused on the leaderboard and the score (Chen, Law, & Huang, 2019).

In another study, Chen et al. (2018) found that 7th-grade science students in the competition group that were using a digital game were using guessing strategies as a method to progress faster through the game. This hindered the learning process and did not foster a deeper understanding of the material. On the other hand, the students in the non-competition group did not have the pressure of the leaderboard. These students were found to use the support tools that were provided in the game. It was discovered that they gained a deeper understanding of the topic. These two studies only focused specifically on 7th-grade students using DGBL in a science classroom. Additional research needs to be done with diverse age groups or different subject areas. The studies also focused specifically on the aspect of using a leader board as competition.

Competition in gaming can put a lot of pressure on students to perform better than their classmates or other competitors who are also playing the same game. This competition may be beneficial for motivating students to succeed, but it could also be detrimental to the students' self-confidence (Chen, Chou, et al., 2012). At the same time, it is also possible to deter students from the attainment of a deeper understanding of the topic at hand. If a student continuously fails while competing in DGBL, it can surely have a negative effect on students' "level of confidence, attitudes, and even belief in future learning" (Chen, Chou, et al., 2012, p. 248). Educators need to be aware that the competitive nature of the game could create a hostile learning environment, which is why educators need to be especially careful when creating groups and partnerships. To have successful groups and partnerships, a positive group dynamic is necessary for the group to collaborate and perform at its best (Chen et al., 2015).

Alternatives to alleviate concerns of students' self-esteem should be explored and utilized when conceivable. One possible alternative is to invoke indirect competition into DGBL. Competition can take on several different forms such as direct and indirect competition. Direct competition involves the students interacting with other competitors and relating directly to their identity (Chen, Chou et al., 2012). For example, students can have their names, pictures, or avatars during the game which helps the students feel involved in the competition. On the other hand, students can use indirect competition by having a "substitute". This substitute character or avatar along with a username or pseudonym can act as a buffer to help students gain more confidence. Chen, Chou, et al. (2012) found that having an alias name gave students' a higher sense of achievement and buffered students' feelings about failure. This could indicate that using tools such as avatars and usernames can help alleviate some of the pressure to help students to perform better. This is very promising because it will also boost healthy, positive competition without too much pressure.

Competition can increase overall performance, perceived competence, and increase effort (Vandercruysse et al., 2013). Competition modes of DGBL can also help improve students' skills as well as evoke more effort and concentration (Chen, 2018). Chen (2018) investigated 7th-grade science students' competition and found that the students that were in collaboration or competition groups performed better than those who played individually. This study was broken down into four modes of game design: individual-competition, individual-no competition, peer-competition, and peer-no competition. When analyzing the intergroup competition, it was found that the students had significantly “higher interest in learning, higher value of the learning, and lower tension during the learning process” than the students who played individually (p. 193). There was no statistical difference between the peer-competition group and the peer-no competition group, however, upon further analysis, it was found that the peer-competition group used “more productive communication and higher quality of collaboration” (p. 194).

Similarly, Admiraal et al. (2011) and Gil-Domenech & Berbegal-Mirabent (2019) found that students who competed in groups outperformed students working individually. The more students are “engaged with competition with other student groups, the more students appeared to learn” (Admiraal et al., 2011, p. 1192). Group competition encourages students to “reach the correct solution before the other teams” which encourages successful completion of the task at hand (Gil-Domenech & Berbegal-Mirabent, 2019, p. 60). Gil-Domenech and Berbegal-Mirabent (2019) also discovered that students found group competition to be more interesting and motivating.

While Chen, Law, and Huang (2019) and Chen et al. (2018) did not find using leaderboards as a successful mean of implementing competition within DGBL, Chen et al. (2012) suggested the implementation of indirect competition by using avatars and usernames to alleviate some pressure and negative connotations with competition. Vandercruysse et al. (2013) and Chen (2018) both found that competition did not have a negative effect on the students’ academic performance. They also noted that it did improve communication, collaboration, student interest, effort, and concentration. With the proper program and implementation, using competition within DGBL has the opportunity to “create contextual learning environments that assist learners in constructing knowledge” (Chen, 2018).

Scaffolds

DGBL has the unique potential to combine rewards, feedback, and scaffolding to optimize the learning experience. The concept of scaffolding learning developed from Vygotsky’s theory of the Zone of Proximal Development to assist the learner to move from “current achievement to new achievement” (Myhill & Warrant, 2005, p. 57). A scaffold is supposed to be temporary support to help the learner “while they acquire the necessary skills and understanding to operate independently” (Myhill & Warrant, 2005, p. 58). Different kinds of scaffolds can enhance multiple aspects of design imagination and creativity (Kao et al., 2017). There are two distinct types of scaffolds that are often used in DGBL: hard scaffolds and soft scaffolds. A soft scaffold is usually provided by the teacher or peers at different times throughout the learning experience and a hard scaffold is usually embedded support provided by the computer at distinct moments during the lesson or activity (Chen & Law, 2016).

Bamberger and Cahill (2013) found that teachers “were concerned about finding a balance between encouraging students to be creative while providing sufficient scaffolding” but scaffolding in DGBL provides a distinctive opportunity to allow for scaffolding and creativity (p. 183). The most common types of a hard scaffold are question prompts to help the students make connections between the information that they know and do not know (Chen & Law, 2016). Hard scaffolds can help students become engaged and “facilitate the construction of conceptual understanding” (Chen &

Law, 2016, p. 1205). The availability of scaffolds is essential to player satisfaction and motivation (Ronimus et al., 2014).

On their own, soft scaffolds have a positive effect on learning performance, however, hard scaffolds can strengthen “the relationship between soft scaffolds and students’ performance” for optimal learning (Chen & Law, 2016, p. 1208). Any DGBL that incorporates scaffolds that “elicit the connection of disciplinary knowledge with knowledge representations embedded in the game” can strengthen the use of game-based learning in the classroom, while also increasing flexibility (Chen & Law, 2016, p. 1208; Kao et al., 2017).

Feedback needs to be consistent and often, especially concerning the progress in the game and skill development (Ronimus et al., 2014). Hung et al. (2014) found that instant feedback can encourage students to achieve academic goals. Any design elements, such as hints and tools, should be clearly labeled to help the students appropriately navigate through the content and game (Kao et al., 2017). The information and feedback should become “available to players at just the time that it is needed to reach each goal” in order to properly scaffold the content that is being delivered (Hamari et al., 2016, p. 170). DGBL enhances and supplements teacher instruction and feedback.

Rewards

Game design elements such as “hints, music, and narratives” as well as “badges, leaderboards, and performance graphs” can have a positive effect on competence and satisfaction (Ku et al., 2016, p. 359; Sailer et al., 2017, p. 377-378). Design components are essential to the learner’s enjoyment, but it is also obvious that learners need to be aware of the elements of game design (Sailer et al., 2017). With straightforward instructions as well as goals that are explicit, age-appropriate, and intellectually relevant, students are sure to gain an understanding of the game itself, as well as the helpful design elements that will ensure maximum satisfaction.

Kober et al. (2020) used different response options for correct and incorrect answers within DGBL. For positive responses, there were gestures such as cheering and raising hands as well as giving the participants virtual coins. For incorrect responses or when participants took too long to respond, the participants lost virtual energy points and were struck by lightning. The participants in this study indicated that the game-based version was more rewarding and these "game elements might have led to stronger reward processing" (Kober et al., 2020, p. 14). The idea of the possibility of gaining positive rewards as well as the threat of negative rewards motivates students to be engaged in the learning process.

When a student advances, digital game-based learning is typically constructed with varying degrees of difficulty. Normally, the levels start easy and become more challenging as the students learn the academic skills required to progress through the game. When students overcome the more challenging levels of the game while receiving rewards, such as digital badges, "the perceived outcome is greater than the invested effort" which makes the learners more likely to continue the game to overcome the more challenging levels (Huang et al., 2010, p. 794). However, if these rewards are only presented at the end of a game, it can be detrimental to motivation (Ronimus et al., 2014).

Teacher-provided feedback and scaffolds, such as questions and comments, as well as embedded rewards and scaffolds, are all shown to have positive effects on learning performance (Chen & Law, 2016). Teachers can support the provided rewards and feedback in the game with their feedback and comments. The teacher feedback should be provided before and during DGBL for the feedback to be most effective (Barzilai & Blau, 2014). DGBL can change the teacher-student relationship by having "the teacher to play a supportive role, rather than that of the opponent" since the game will be giving the assessment feedback (Sykes, 2006, p. 4). Educators need to ensure that they provide adequate and clear feedback on the DGBL that they implement so that the learners can stay inspired and interested in the content.

Chapter 2 Summary

Many studies have been concluded and some have shown promising benefits to DGBL including an increase in prefrontal brain activation. DGBL has even been shown to increase prefrontal brain activation which in contrast to non-game-based learning, this may mean a greater emotional attraction and engagement, as well as the potential to draw participants' interests (Kober et al., 2020).

DGBL combines the knowledge and past experiences that students have already attained with new and stimulating content that they will attain. The students' engagement and academic performance can be improved through challenge and competition, while also enjoying the gaming activities. DGBL can provide academic performance and learning success while also providing teachers with evidence to support student development and learning.

In mathematics, DGBL has been shown to maintain academic achievement but more often it has been shown to improve it. Increased engagement, motivation, enjoyment, collaboration, and progression through content are only a few of the other advantages of integrating DGBL into a mathematics classroom.

Digital games can be customized and personalized for optimal student learning. When choosing and implementing DGBL there are many other factors, besides technical skill level, that must be considered such as background and content knowledge. DGBL can differentiate the academic content of the game, as well as the game preferences, to allow students to take an active part in their learning experience. Digital games can include features such as rewards, scaffolding, competition, customization, and personalization.

Competition is beneficial in motivating students but could also be detrimental to the students' self-confidence if not implemented correctly. The game must boost healthy, positive competition without diminishing students' self-confidence. Overall efficiency, perceived competence, and initiative can all be improved by competition within DGBL. Competition can also involve collaboration and groups of students. Group competition can be more captivating and stimulating as opposed to students working individually.

Feedback and scaffolds provided by the teacher, such as questions and comments, as well as embedded rewards and scaffolds, have all been shown to improve learning performance. Some in-game feedback may be the use of badges, digital rewards, leaderboards, gestures, points, etc. Through DGBL the idea of gaining positive rewards as well as the threat of negative rewards can be a great motivating factor. Students will develop an appreciation of the game itself, as well as the beneficial design elements that will ensure enjoyment with a reward scheme, thanks to explicit directions and goals, and age and intellectually related objectives.

Student engagement in DGBL has an important outcome on game activity, enjoyment, and academic achievement. In DGBL, players consciously and intentionally work out various tactics in order to accomplish a challenge successfully. Engagement can be measured a number of different ways, with one example as the number of tasks completed and the time spent on the game. DGBL can take on many different forms, but no matter what the storyline is, it is necessary to have a seamless integration of the educational content and game design.

Collaborating with other players is another aspect that can encourage engagement among students. It is essential for students to be able to work together and come up with a conclusive result. Social interactivity is a real-world situation that should be reinforced regardless of using DGBL or in an interactive classroom setting. Communication and problem solving are essential for collaborating ideas. Also, to optimize engagement, educators need to ensure that the students are grouped appropriately to help create the most effective learning groups. DGBL can engage students in collaborative learning which can help students build relationships as they struggle and eventually master the games and content. This literature review provided a foundation for the methodology of the current study. The following chapter will outline the methodology that will be used in this study.

CHAPTER THREE: METHODOLOGY

Introduction

The focus of this explanatory sequential mixed methods study was to determine how students' prior engagement was related to their academic achievement in mathematics while utilizing DGBL. This study also investigated students' motivation, based on their autonomy, competence, relatedness, and engagement. The participants in this study consisted of sixth, seventh, and eighth-grade students, so as part of the analysis, differences in academic achievement between respective grade levels were considered to determine if students in a particular grade level performed better using DGBL. Motivation was analyzed to determine if there was any effect on academic performance for mathematics students utilizing DGBL within or between particular groups. This study also analyzed and investigated students' motivation for applying DGBL in mathematics based on their autonomy, competence, and relatedness. The following chapter will provide a detailed description of the methods that were used to collect and evaluate the data through questionnaires, surveys, and assessments.

Using an explanatory sequential mixed methods design allowed for quantitative data to be collected first, assessed, and then evaluated against qualitative data to help further clarify the quantitative results (Subedi, 2016). The preliminary quantitative portion of the study comprised various aspects of data collection for the purpose of identifying students' engagement. The students completed a modified version of the National Survey of Student Engagement (NSSE) to identify their engagement prior to the intervention (Appendix D). Following this survey, the students completed a mathematics quantitative pretest to assess their current academic level. The sixth-grade pretest (Appendix A) assessed students' knowledge of fraction operations, decimal operations, percents, and exponents. The seventh-grade pretest (Appendix B) assessed students' knowledge of integer operations and expressions with fractions and decimals. The eighth-grade pretest (Appendix C) assessed students' knowledge of solving equations, linear equations, and linear graphs.

DGBL was utilized once per week during one-hour sessions over a ten-week period. Following the completion of the program, each student was given a quantitative posttest (Appendices A, B, and C) to assess academic growth. Upon completion of the analysis of academic growth, the researcher began the qualitative phase of the research process. During the qualitative phase, data were collected as a follow-up in the form of a survey (Appendix E) to help explain the quantitative results. In this explanatory follow-up, the researcher gained a better understanding of the students' motivation for DGBL in a middle school mathematics classroom.

Research Methods

The research methodology design was an explanatory sequential mixed methods design. As opposed to completing a quantitative or qualitative study, a mixed method study combined both methods to collect closed-ended and open-ended data in response to the research questions. By using a mixed methods approach, it minimized the limitations of qualitative and quantitative research on their own (Gelo et al., 2008). Using a mixed methods approach reduced qualitative and quantitative research constraints by adopting a hybrid methodology. The mixed methods research context and questions that were used were complex, which made it a good approach to use to better grasp the research problems/question of the study (Creswell, 2014).

The use of a mixed methods approach became popular in the late 1980s and early 1990s in several fields, including education (Creswell, 2014). It has since been scrutinized and has now become an acceptable form of research in different areas of study around the world. It allows for multiple worldviews and paradigms while exploring "different and more complex questions and, consequently, looking for different and more complex answers" (Gelo et al., 2008, p. 279). Mixed methods have been used by researchers as a way to overcome the critiques of quantitative and qualitative methods (McKim, 2017).

The qualitative and quantitative data were collected and analyzed through a rigorous process that included adequate sampling, multiple sources of information, and detailed data analysis steps. Mixed methods research is a complex approach and was "a useful strategy to have a more complete understanding of research problems/questions" (Creswell, 2014, p. 267).

Mixed methods research does pose some research challenges. The main challenge is the amount of time required to collect and analyze quantitative and qualitative data (Creswell, 2014; Ivankova et al., 2006). For this particular study, there was only one researcher that conducted the study, collected the data, and analyzed the data, which required an extensive amount of time as well as knowledge of quantitative and qualitative procedures. Lastly, due to the complexity of the design, to be as transparent as possible, the researcher provided "visual models to understand the details and the flow of research activities in the design" (Creswell, 2014, p. 267). A graphical model "might lead to better understanding of the characteristics of the design, including the sequence of the data collection, priority of the method, and the connecting and mixing points of the two forms of data within a study" (Ivankova et al., 2006, p. 4).

Research Design

The design for this research was a mixed methods explanatory sequential design. The quantitative data and conclusions gave a general overview of the research topic. The qualitative data collection was then used to expand on these results and was used to help explain and clarify the research topic. The explanatory sequential method was useful to help clarify and explain the statistical results by studying participants in more detail together with quantitative data and qualitative data (Subedi, 2016). Despite the time-consuming process, the explanatory sequential mixed methods design of this study allowed for a more well-rounded result (Miles et al., 2020).

This mixed methods explanatory sequential design served to answer the following research questions:

1. How does utilizing DGBL within mathematics affect students' academic achievement in 6th, 7th, and 8th grades?
2. Is there a relationship between students' prior engagement and their academic achievement after utilizing DGBL in a middle school mathematics setting?
3. How does the students' motivation, based on autonomy, competence, and relatedness, help explain students' academic achievement and engagement with the use of DGBL?

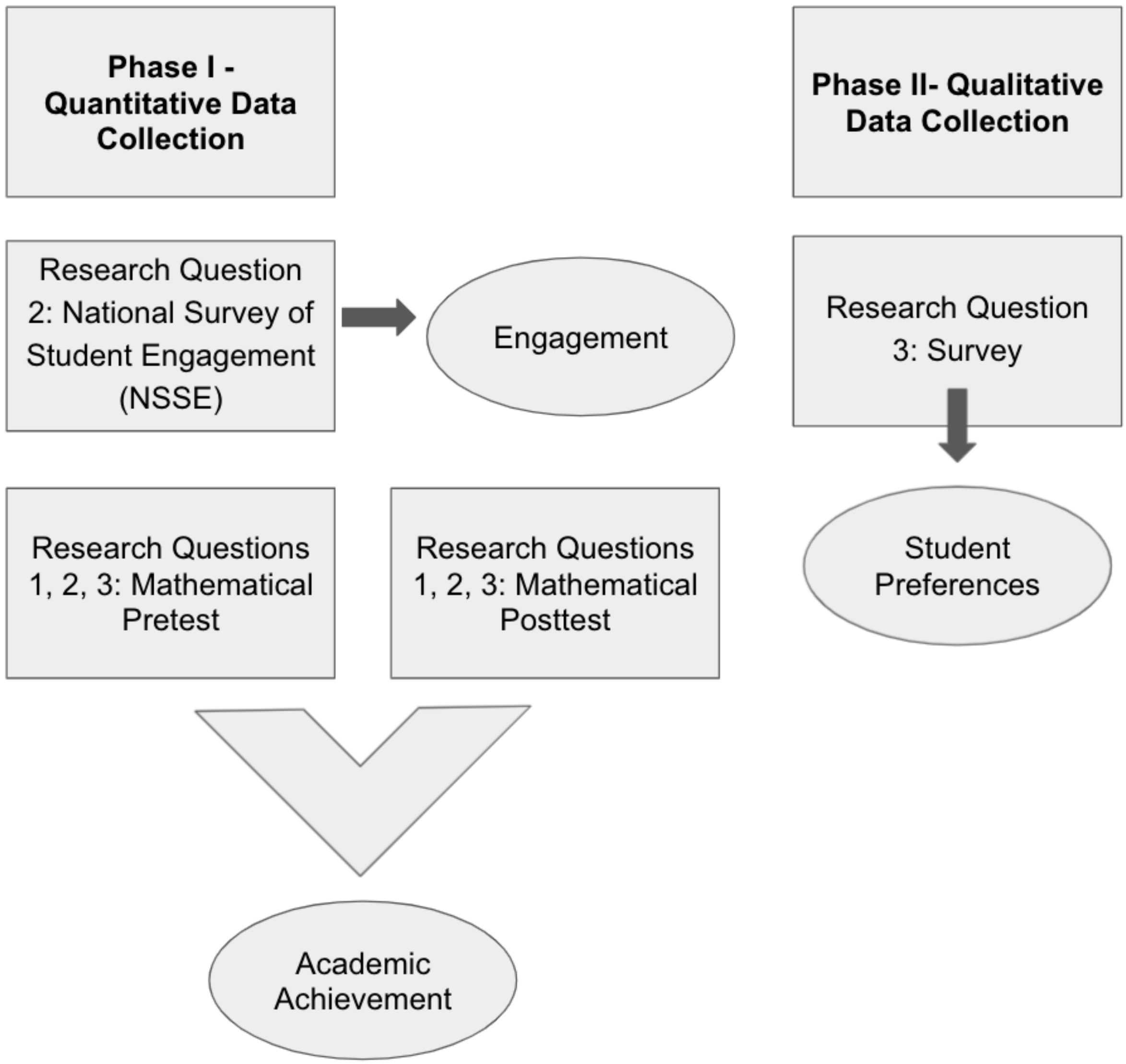

Figure 3 Visual Model: Flow of Explanatory Research Design

As shown in Figure 3, in the explanatory sequential design, there were two phases: a quantitative phase followed by a qualitative phase. During the first phase, quantitative data was collected from a questionnaire as well as a pretest and posttest. This data was then analyzed prior to the start of the second phase. During the second phase, qualitative data was collected from open-ended surveys with the students. By using an explanatory sequential mixed methods approach, it provided “opportunities for the exploration of the quantitative results in more detail” (Ivankova et al., 2006, p. 5).

Using an explanatory sequential mixed methods design allowed for quantitative data to be collected first, and then the qualitative data was used to help explain the quantitative results. The first quantitative portion of the study involved several aspects of data collection to identify students' prior engagement. The students completed a quantitative survey to identify their engagement, which was measured using a modified version of the National Survey of Student Engagement (NSSE). This survey was first developed in 1998 and was most recently updated in 2013. Initially, the Pew Charitable Trusts funded the project and worked with higher education leaders. The survey was then revised by the Design Team and was analyzed by several groups and accreditation agencies such as the Middle States Association, higher education oversight agencies, and the American Council on Education, as well as representatives from potential participating colleges and universities ("NSSE Origins and Potential", 2001).

This survey has been through several rounds of revision as well as extensive testing to ensure that it was a valid and reliable source of information with extensive research backing (Fosnacht & Gonyea, 2018). When the survey was first developed, there was a gathering in Washington, D.C. with accreditation agencies, higher educational agencies, and the press. Following this meeting, there were two additional stakeholder meetings with the Council of Independent Colleges and the Annapolis Group. Besides these meetings, there were hundreds of students at several different institutions that participated in focus groups and cognitive interviews (Fosnacht & Gonyea, 2018).

This survey allowed for the collection of information with regards to students' participation and engagement in their learning. There were ten engagement indicators in the survey, with four main themes. The first theme was academic challenge, which consisted of four engagement indicators: higher-order learning, reflective and integrative learning, learning strategies, and quantitative reasoning. The second theme was learning with peers, which encompassed two engagement indicators: collaborative learning and discussions with diverse others. The third engagement theme was experiences with faculty, which consisted of two engagement indicators: student-faculty interaction and effective teaching practices. The final engagement theme was campus environment, which also consisted of two engagement indicators: quality of interactions and supportive environment. These engagement themes were then used to identify information about specific aspects of student engagement.

This survey collected data that was related not only to students' in-class engagement, but also engagement within the school. This allowed for a holistic approach to each student with regards to their individual education. This survey was also particularly appropriate for this study since the study involved a smaller population. The NSSE survey can be reliably generalized from a smaller population and still produce dependable statistics (Fonsnacht & Gonyea, 2018). The survey provided the opportunity for the researcher "to investigate the level of student engagement in a variety of subpopulations" (Fonsnacht & Gonyea, 2018, p. 71). The researcher was able to establish if certain groups of students or students with specific characteristics, as determined by the modified NSSE questionnaire, had a stronger academic performance while using DGBL.

Following this questionnaire, the students completed a mathematics quantitative pretest to identify their current academic level. The pretests were created by the researcher using the Big Ideas Learning Mathematics curriculum, following the state mathematics standards. There was one pretest per grade level, which consisted of fifteen questions each. The sixth-grade pretest (Appendix A) assessed students' knowledge of fraction operations, decimal operations, percents, and exponents. The seventh-grade pretest (Appendix B) assessed students' knowledge of integer operations and expressions with fractions and decimals. The eighth-grade pretest (Appendix C) assessed students' knowledge of solving equations, linear equations, and linear graphs.

After the completion of the questionnaire and the pretest, the students began using Prodigy, which was an adaptive, self-paced digital mathematics game that was set in a fantasy wizard world. The students utilized the DGBL once per week for an hour during each session over a ten-week period. During this intervention, students were working on different mathematics topics to meet their own needs. For example, sixth-grade students were learning about decimal operations, fraction operations, exponents, and percentages, seventh-grade students were learning about integer operations and expressions with fractions and decimals, and eighth-grade students were learning about solving equations, linear equations, and linear graphs. Following the completion of the program, the students were given a quantitative posttest to access their academic growth in these content areas.

The researcher then began the qualitative phase of the research process. The qualitative data was collected as a follow-up to help explain the quantitative results. In this explanatory follow-up, the researcher explored the students' motivation while using DGBL in a middle school mathematics classroom based on their competence, relatedness, and autonomy. This took place in the form of an open-ended survey (see Appendix A).

The open-ended survey questions were developed based on the self-determination theory (SDT), specifically analyzing students' competence, relatedness, and autonomy. These questions were derived based on the SDT research and surveys from the quantitative questionnaires developed by the Center for Self-Determination Theory (CSDT). CSDT is a non-profit organization dedicated to disseminating the concept, research, and best practices of SDT. CSDT provides research on "supporting the basic psychological needs and creating the best possible climates for deeper and more effective motivation, engagement, and wellness" (The Theory, 2021). CSDT has developed a library of articles and best practices as well as research topics to learn more about applying SDT within different fields of study.

The CSDT has also provided different metrics and methods with questionnaires that have been developed to "assess different constructs contained within the theory" ("Metrics & Methods: Questionnaires, 2021). These questionnaires were all validated through research and were available for use in academic research projects. However, each of these questionnaires consisted of closed-ended questions. For the qualitative portion of the study, the researcher used the provided quantitative questionnaires as a guide to develop and structure the open-ended survey questions.

Specifically, the researcher used the Intrinsic Motivation Inventory, the Self-Regulation Questionnaire, the Basic Psychological Need Satisfaction and Frustration Scale, and the Index of Autonomous Functioning questionnaires. Each of these questionnaires have been validated independently. The Intrinsic Motivation Inventory focuses on intrinsic motivation and self-regulation and has been used in several research studies since 1982 (Ryan, 1982; Ryan et al., 1983; Plant & Ryan, 1985; Ryan et al., 1990;

Ryan et al., 1991; Deci et al., 1994). The validity and reliability of this questionnaire was evaluated in 1989 and again in 2003 (McAuley et al., 1989; Tsigilis and Theodosiou, 2003). Both studies found this questionnaire found strong support for its reliability and validity. The Self-Regulation Questionnaire examines individual variations in motivation and regulation styles. This questionnaire was validated by Ryan and Connell (1989) and again in by Levesque et al. (2007). The Basic Psychological Need Satisfaction and Frustration Scale was developed by Chen et al. (2015) which is used for assessing the basic psychosocial needs within SDT. This questionnaire was validated by Olafsen et al. (2021). The Index of Autonomous Functioning Questionnaire is used to measure autonomy. Weinstein et al. (2012) completed a study that led to the validation of the Index of Autonomous Functioning Questionnaire.

Keywords were identified from these questionnaires to create the open-ended questions for the survey that specifically related to DGBL. For example, some keywords in the perceived competence questions were “satisfied, skills, and performance”, relatedness questions often used the word “interactions”, and autonomy questions used the word “choice”. In one case, the perceived competence question developed by CSDT was “I am satisfied with my performance at this task”, which was modified to be “How satisfied are you with your performance throughout the game?”. There were ten open-ended questions that were developed for the open-ended survey.

Participants and Settings

This study took place in a public middle school within the northeastern area of the United States. The K-8 school district is composed of six elementary schools and two middle schools, with approximately 4,800 students enrolled in the public school system. The particular school where this study was conducted includes sixth through eighth-grade middle school students from a suburban town with a population of about 40,200 people. There are approximately 1,000 general education and special education students that attend the public middle school.

Voluntary sampling was used since the researcher sought student participants to voluntarily enroll in an after-school DGBL mathematics club. This club was facilitated by the technology teacher, who previously taught mathematics for over ten years. The club was open to any student in sixth through eighth grade who wanted to join and was held after school hours. The students had different mathematics teachers and had different prior knowledge of mathematics. The students were enrolled in different levels of mathematics courses, such as co-teaching, on grade-level, and above grade-level classes. With parental consent, the students voluntarily took part in this study while participating in the afterschool program.

Within the school, there were different mathematics courses per grade level. For special education students, there were resource or co-teaching classes. The resource classes were smaller in size and were taught by a special education certified teacher with only special education students. In a co-teaching class, there were two teachers: a general education teacher and a special education teacher. These classes usually have a larger number of students and were composed of both special education and general education students. For general education students, there were three levels of classes per grade level. The classes were titled B, C, or Accelerated. A B-level class was a general education, on-grade level class with one general education teacher. A C-level class was a general education, above grade-level class with one general education teacher. For example, if a sixth-grade student was in a C level class, they would be learning seventh-grade mathematics. An Accelerated-level class was a general education class that was two grade levels above. For example, if a sixth-grade student was in Accelerated mathematics, the students were learning eighth grade mathematics.

The DGBL mathematics program was a ten-week club that ran from November 2021 through January 2022. The club met with all members once per week for one hour. The researcher was the advisor of the club and was responsible for introducing the program, monitoring progress, and collecting and analyzing data. During this time, the participants were engaged in the online educational mathematics platform Prodigy.

Prodigy is a role-playing game where students create their own wizard and compete against monsters (the computer) or other students. Once a student wins a battle by correctly answering a question, they earn rewards to unlock prizes. Students can travel through different wizard worlds, chat with other wizards (their classmates) and challenge wizards, all while working on mathematics topics. As students' math skills become stronger, so does their wizard, who will develop new spells. The questions are adjusted to the students' abilities, so students of different ability levels can still battle each other, but they will receive their own personalized content.

Teachers can allow the program to provide content based on the students' academic performance in the program, or the teacher can create assignments based on state standards. For example, a teacher can select a specific skill that they want the whole class to work on or have students work based on areas of low academic proficiency. There is a detailed teacher dashboard that allows the teacher to create classes, or sync classes from Google Classroom, view reports, view live dashboards, and create assessments.

Data Collection

The use of one quantitative questionnaire was used to identify the students' prior engagement. A pretest and posttest were used to show mathematical growth and the variables were analyzed to determine if students with certain characteristics, such as grade level, mathematics class placement, had a higher increased mathematical achievement. Finally, to determine students' motivation with DGBL, students completed a qualitative survey. The survey was used to determine students' motivation for DGBL in a middle school mathematics setting.

The National Survey of Student Engagement

The National Survey of Student Engagement (NSSE) is a quantitative survey that was modified and used to measure student engagement (Appendix D). This survey has undergone multiple rounds of modification and rigorous testing to guarantee that it is a legitimate and trustworthy source of information with significant research support (Fosnacht & Gonyea, 2018). The study used the Generalizability Theory and found that analyzing the NSSE Engagement Indicators' by the means can be extended to a wider population from a smaller sample size, which ensure that the Engagement Indicators are dependable measurements of engagement (Fosnacht & Gonyea, 2018). When the survey was initially established, accreditation agencies, higher-education agencies, and the press gathered in Washington, D.C. Following this meeting, the Council of Independent Colleges and the Annapolis Group held two further stakeholder sessions. Aside from these sessions, hundreds of students participated in focus groups and cognitive interviews at other universities (Fosnacht & Gonyea, 2018).

The NSSE emerged in the late 1990s and was officially launched in 276 colleges and universities in 2000 (Ewell & McCormick, 2020). The original goal of the NSSE was to provide a more accurate way of evaluating college quality. Student engagement was segregated into two parts. The first part is in relation to the students' efforts and the time that they put into their education. The second part is in regard to how the school establishes its resources, curriculum, and learning opportunities in order to attain student engagement (Ewell & McCormick, 2020). The results of these surveys were used for a multitude of reasons, such as "accreditation, quality improvement, benchmarking, studies of retention and graduation, and routine assessment" (Kinzie & Franklin, 2020, p.4). Most importantly, these surveys can be used to identify students or groups of students, which can give schools an opportunity to take action to improve their experience.

The NSSE survey has been modified from its current version to ensure that it is appropriate for middle school students. The original survey was developed to assist colleges and universities in identifying the level of student participation and engagement in the United States and Canada. The researcher modified the survey to include sixty-six Likert scale questions suitable for middle school students. Particular terms and phrases that only apply to higher education students were adjusted to fit the middle school participants (Appendix D).

Some examples of these changes are: “course” was changed to “class” throughout the survey, “instructors” was changed to “teachers”, and “institution” was changed to “school”. Some other questions were eliminated that did not apply, such as questions involving graduation, internships, etc. This survey was administered through a Google Form during the first week of the DGBL program.

As shown in Table 1, the survey identified four major engagement themes. Academic challenge was the first theme, which had four engagement indicators: higher-order learning, reflective & integrative learning, learning strategies, and quantitative reasoning. Learning with peers was the second theme, which included two engagement indicators: collaborative learning and discussions with diverse others. Experiences with faculty was the third engagement theme that encompassed two engagement indicators: student-faculty interaction and effective teaching practices. The last theme was campus environment, which consisted of two engagement indicators: quality of interactions and supportive environment.

Table 1 Engagement Themes and Indicators

Engagement Themes	Engagement Indicators			
Academic Challenge	Higher-Order Learning: Measured the amount of demanding cognitive activities that students were required to complete through their classes	Reflective & Integrative Learning: Analyzed connecting students' understanding to the material and their experiences	Learning Strategies: Actively engaged with and evaluated class material in order to learn and retain the information	Quantitative Reasoning: Assessed the students' engagement with analyzing, defending, and critiquing ideas based on numerical and statistical data
Learning with Peers	Collaborative Learning: Identified activities such as group projects and asking others for help as key factors to prepare students to work through difficult situations	Discussions with Diverse Others: Analyzed the opportunities that students have to interact with and learn from people with different backgrounds and experiences		
Experiences with Faculty	Student-Faculty Interaction: Identified the interactions with teachers, faculty, and students to help students create links between their education and their long-term goals	Effective Teaching Practices: Analyzed the instruction, explanations, examples, and feedback that educators provide to students to encourage student understanding and learning		
Campus Environment	Quality of Interactions: Evaluated the environment and positive interactions with	Supportive Environment: Gauged the amount of cognitive, social, and physical		

	peers, teachers, and staff to help students learn from others and find help if they need it	support the school provides		

The higher-order thinking engagement indicator through the NSSE measured the amount of demanding cognitive activities that students were required to complete through their classes. Reflective and integrative learning was an engagement indicator that analyzed connecting students' understanding to the material and their experiences. The educators encouraged students to make connections between their learning and the world around them by rethinking their own views and challenging and exploring ideas from other viewpoints. The learning strategies engagement indicator emphasized actively engaging with and evaluating class material in order to learn and retain the information. This could help schools identify interventions to improve student learning and achievement. The final engagement indicator in the academic challenge theme was quantitative reasoning. This indicator assessed the students' engagement with analyzing, defending, and critiquing ideas based on numerical and statistical data.

Within the learning with peers theme, the engagement indicator of collaborative learning identified activities such as group projects and asking others for help as key factors to prepare students to work through difficult situations. The other engagement indicator within the learning with peers theme was discussions with diverse others, which analyzed the opportunities that students have to interact with and learn from people with different backgrounds and experiences.

Experiences with faculty was the third engagement theme. The first engagement indicator within this theme was student-faculty interaction, which identified the interactions with teachers, faculty, and students to help students create links between their education and their long-term goals. The effective teaching practices engagement theme analyzed the instruction, explanations, examples, and feedback that educators provide to students to encourage student understanding and learning.

The final theme of campus environment had two engagement indicators: quality of interactions and supportive environment. Quality of interactions evaluated the environment and positive interactions with peers, teachers, and staff to help students learn from others and find help if they need it. A supportive environment is gauged the amount of cognitive, social, and physical support the school provides. The information regarding various areas of student engagement was then gathered using these engagement indicators.

Pretest and Posttest

The pretest and posttest were created by the researcher to show academic growth (Appendices A, B, and C). The researcher was a certified mathematics teacher with over a decade of teaching experience as well as experience in creating and modifying curricula. The researcher created three different quantitative tests (one per grade level) based on the mathematics content that the students were learning from September through December. For example, sixth-grade students were learning about decimal operations, fraction operations, exponents, and percentages, seventh-grade students were learning about integer operations and expressions with fractions and decimals, and eighth-grade students were learning about solving equations, linear equations, and linear graphs. Every assessment was aligned with the state learning standards for mathematics, and each question was developed by the Big Ideas Math program and chosen by the researcher to be a part of the assessment. Each assessment consisted of fifteen multiple-choice questions. The pretest was administered during the second week of the DGBL program. The posttest was administered during the tenth week of the program.

Student Motivation

The student motivation survey was a qualitative Google Form that was created by the researcher to help determine the students' motivation for DGBL to explain the quantitative results. It consisted of ten open-ended questions based on the students' autonomy, competence, and relatedness (Appendix E). This survey was based on the quantitative surveys provided by the Center for Self-Determination Theory (CSDT). CSDT is a non-profit organization committed to disseminating the concept, research, and best practices of SDT. CSDT has compiled a collection of publications, best practices, and research topics for those interested in learning more about applying SDT to different disciplines of study.

Additionally, CSDT provided questionnaires that have been developed and tested through research to use for academic research purposes. These questionnaires were quantitative, which is why the researcher used the questionnaires as a guide to develop and structure the open-ended survey questions. The researcher used the Intrinsic Motivation Inventory, the Self-Regulation Questionnaire, the Basic Psychological Need Satisfaction and Frustration Scale, and the Index of Autonomous Functioning to develop the open-ended questions. The open-ended questions for the survey and those especially linked to DGBL were created using keywords from these surveys. For example, some keywords in the perceived competence questions were "satisfied, skills, and performance", relatedness questions often used the word "interactions", and autonomy questions used the word “choice”. In one case, the perceived competence question developed by CSDT was “I am satisfied with my performance at this task.”, which was modified to be “How satisfied are you with your performance throughout the game?”.

Data Analysis

Two programs were used to analyze the data that was collected: SPSS and NVivo. SPSS was used to analyze the quantitative data, while NVivo was used to analyze the qualitative data. The data was stored in multiple locations to ensure that no information was lost. The data was stored in Google Drive, on a hard drive, and in SPSS and NVivo. Since this was an explanatory sequential mixed methods design, the quantitative data was collected and analyzed first.

Table 2 Data Collection and Analysis

Research Question	Data Collection Instrument	Data Analysis Process
How does utilizing DGBL within mathematics affect students' academic achievement in 6th, 7th, and 8th grades?	Pretest & Posttest	All students: Paired t-test Grade Levels: Kruskal-Wallis Test Math Levels: Kruskal-Wallis Test
Is there a relationship between students’ prior engagement and their academic achievement after utilizing DGBL in a middle school mathematics setting?	Pretest/Posttest Results Modified NSSE Survey	Multiple Linear Regression
How does the students’ motivation, based on autonomy, competence, and relatedness, help explain students’ academic achievement and engagement with the use of DGBL?	Pretest/Posttest Results Modified NSSE Survey Motivation Survey	First Cycle/Structural Coding Second Cycle Coding Pearson’s Correlation Test (Combined Results)

To answer all three research questions, the pretest and posttest scores were collected through Google Forms. This data was organized and analyzed according to grade levels and math levels in SPSS. As shown in Table 2, to answer the first research question, “How does utilizing DGBL within mathematics affect students' academic achievement in 6th, 7th, and 8th grades?”, the pretest and posttest were analyzed using SPSS. A paired t-test was used to determine the overall academic achievement among all of the eighteen participants. The paired t-test was used to compare the pretest data and the posttest data in SPSS to determine if there was a significant difference between the pretest and posttest scores after the DGBL intervention. Following the paired t-test, a Kruskal-Wallis test was used with each of the subgroups of students within different grade levels (6th, 7th, or 8th) and students within different mathematics levels (B, C, or Accelerated). This was used to determine if students within a specific grade level or mathematics level would benefit most from DGBL.

As shown in Table 2, to answer the second research question, “Is there a relationship between students’ prior engagement and their academic achievement after utilizing DGBL in a middle school mathematics setting?”, the modified NSSE survey was collected through a Google Form. This data, along with the pretest/posttest results, were entered into SPSS to be analyzed and compared. A multiple linear regression test was used to analyze this data to determine if there was a relationship between academic achievement and students’ prior engagement. Initially, all of the data was collected and analyzed independently of one another.

As shown in Table 2, to answer the third research question, “How does the students’ motivation, based on autonomy, competence, and relatedness, help explain students’ academic achievement and engagement with the use of DGBL?”, the survey was collected through open-ended questions using Google Forms. NVivo was used to store, code, and run queries on this qualitative data. The surveys were uploaded to NVivo to prepare for first-cycle coding as a technique to digest the data (Miles et al., 2020). Structural coding was used with the predetermined themes of autonomy, competence, and relatedness. Structural Coding was used as a method of applying a preset list of codes to the content based on the research question that was used to structure the survey questions (MacQueen & Guest, 2008). Since the questions for this survey were developed based on the self-determination theory’s motivational components of autonomy, competence, and relatedness, these components were used as the themes for structural coding. The students' motivation was assessed using these themes, with each question relating to a different component of motivation. Coding was used to help the researcher find and group similar data sets to prepare for more detailed coding and analysis.

Once the first-cycle coding was completed, the researcher began the second-cycle coding to group the initial codes into more specific themes. Parent and child codes were created to group and categorize codes appropriately (Gibbs, 2007). The researcher maintained awareness of the importance of maintaining the context of the data while consolidating it. Analyzing the qualitative research was an “evolutionary journey” where the researcher expected various concepts to appear throughout the coding process, which may even change the direction of the research (Birks, Chapman & Francis, 2008, p. 71). This was particularly true for an explanatory sequential mixed methods study due to the qualitative data being used to explain the results of the quantitative data (Subedi, 2016).

The qualitative data from the open-ended survey was then merged with the quantitative data to determine if there was a relationship between student motivation, based on autonomy, competence, and relatedness, academic achievement, and prior engagement. As shown in Table 2, to analyze this data, the researcher used inter-rater reliability and was assisted by two other teachers to score the open-ended motivational survey (Lim et al., 2012). Both of these teachers each have a Master's degree in Educational Technology and are familiar with collecting and analyzing data. A fully crossed design was used where the same three teachers (the researcher and two others) all rated each question for each student (Hallgren, 2012). Using this method, each student was able to receive a score for each of the motivational categories of autonomy, competence, and relatedness. A Pearson's correlation test was then run in SPSS to compare the four engagement themes (academic challenge, learning with peers, experiences with faculty, and campus environment) to academic achievement, as well as motivation, based on autonomy, competence, and relatedness.

Ethical Considerations

The researcher remained objective and transparent throughout the process. When reporting the findings, the researcher used explicit language to explain all of the steps that were followed in the collection and analysis stages of the research. The results portion of the study had enough documentation and description of all of the procedures to be easily examined by the reader (Miles et al., 2020).

When reporting the findings from the questionnaire, pretest, posttest, and surveys, the researcher used thick descriptions to merge "the participants' lived experiences with the researcher's interpretations of these experiences" (Ponterotto, 2006, p. 547). These explanations can then assist the reader in determining whether or not they may have reached the same conclusions.

Once the data was collected, triangulation was used to "collect and double-check findings, using multiple sources and modes of evidence" to verify the data collection process (Miles et al., 2020, p. 294). The data was collected from multiple sources and in multiple formats to remain consistent and objective. The researcher showed rigor through the data collection and analysis process to be "better equipped to make smart choices about samples and contexts that are appropriate or well poised to study specific issues" (Tracy, 2010, p. 841).

There were ethical issues that had to be addressed before, during, and after the study. A consent form was sent home to parents/guardians since the study involved sixth, seventh, and eighth-grade students. The consent form had a detailed description of the study and explained how the researcher would help protect the students' identities. Parent/guardian consent was challenging to obtain from the entire group of students enrolled in the DGBL club. This eliminated some potential participants, but there were still eighteen participants eligible to participate in the study. The students were also asked if they would like to participate in the study.

During and after the study, the students remained anonymous. For example, while collecting the data from the pretest, posttest, modified NSSE, and motivation survey, the students were assigned an ID number that the researcher used to track student growth. At no point throughout the research were the names of the students, town, or school published.

Another consideration was the support of the administration/district. This particular program, Prodigy, is free for districts to use; however, many game-based learning programs are subscriptions that need to be paid for by the district/administration. Even though DGBL can benefit the district in the long term, the district's budget is usually very tight. It would be beneficial for the district to invest in a digital game-based learning program. However, there would need to be enough money in the budget to do so. To alleviate any concerns from the school district, the researcher met with the administration prior to collecting any data to inform and educate the administration about the benefits of DGBL.

Chapter 3 Summary

This study involved eighteen sixth, seventh, and eighth-grade students in a suburban middle school in the northeastern area of the United States. The students volunteered to participate in an after-school DGBL mathematics club. The researcher met with the participants once per week for an hour each time over the course of the ten-week intervention. During this time, the students played the DGBL program Prodigy. Prodigy is an interactive quest-based game where the academic content was differentiated for each of the individual learners.

The research design was an explanatory sequential mixed methods design, which allowed for both quantitative and qualitative data to be collected. By adopting a mixed methods technique, the qualitative and qualitative research restrictions were lessened.

The quantitative data was collected first, which consisted of the modified NSSE questionnaire, the pretest, and posttest. To determine students' prior engagement, the modified NSSE questionnaire was administered through a Google Form. The students then completed the mathematical pretest based on the students' current grade level. After the students utilized the DGBL program Prodigy for eight weeks, the students completed the mathematics posttest. The pretest and posttest consisted of fifteen multiple-choice questions that were developed by the Big Ideas Mathematics Curriculum, backed by the state standard, and chosen by the researcher. The pretest/posttest were used to determine students' academic achievement.

The qualitative data was then collected through an open-ended survey to determine the students' motivation for using DGBL, based on autonomy, competence, and relatedness. The open-ended survey consisted of ten questions based on the self-determination theory. The data were analyzed by the researcher using the statistical programs SPSS and NVivo. The following chapter will provide a detailed explanation of the findings from the study.

CHAPTER FOUR: FINDINGS

Introduction

The purpose of this explanatory sequential mixed methods study was to determine how prior engagement affects academic achievement and to investigate students' motivation, based on autonomy, competence, and relatedness, with the use of DGBL in mathematics. The explanatory sequential design allowed for quantitative data to be collected first, followed by qualitative data. The quantitative data consisted of a pretest, a posttest, and the modified NSSE survey. The qualitative data consisted of an open-ended survey as a follow-up to the quantitative phase of the research. This study was used to help answer the following research questions:

1. How does utilizing DGBL within mathematics affect students' academic achievement in 6th, 7th, and 8th grades?
2. Is there a relationship between students' prior engagement and their academic achievement after utilizing DGBL in a middle school mathematics setting?
3. How does the students' motivation, based on autonomy, competence, and relatedness, help explain students' academic achievement and engagement with the use of DGBL?

The following chapter provides an analysis of the findings from the data collection. The first phase involved the collection and analysis of the quantitative data which consisted of the pretest, posttest, and the modified NSSE questionnaire. These results were used to determine the effectiveness of DGBL on academic achievement and prior engagement. The second phase consisted of the collection and analysis of the qualitative results, the open-ended survey. The phase two results were then used in conjunction with the phase one results to analyze student motivation, based on autonomy, competence, and relatedness.

Phase I Analysis

During the first phase of the research, all eighteen middle school participants completed a fifteen-question, multiple-choice pretest prior to the DGBL intervention. There were three versions of the pretest based on grade level. The pretest questions were developed by the Big Ideas Mathematics program and chosen by the researcher based on the state mathematics learning standards.

The students also completed the modified NSSE survey prior to the DGBL intervention. This survey consisted of sixty-six Likert scale questions that were adjusted to be suitable for middle school students. The original survey was intended for college and university students, so specific terms such as “instructors” were changed to “teachers” to make the survey more relatable to the middle school participants.

The students utilized the DGBL mathematics program Prodigy during a ten-week after-school program. The students volunteered to join the program, and parental consent was obtained prior to the study. After the intervention, the students completed a fifteen-question, multiple-choice posttest to determine if there was academic growth due to the DGBL intervention. There were three versions of the posttest based on grade level. The posttest questions were developed by the Big Ideas Mathematics program and chosen by the researcher based on the state mathematics learning standards.

During the analysis of the phase one data, pretest, posttest, and the modified NSSE questionnaire, the researcher used various methods to appropriately analyze the data based on the sample size and the information that was collected. All of the data was collected through Google Forms, which were then exported to Google Sheets and finally Microsoft Excel to allow for a seamless transition to SPSS Statistics.

Academic Achievement

The first research question, "How does utilizing DGBL within mathematics affect students' academic achievement in 6th, 7th, and 8th grades?" had several components to it. The first aspect that was analyzed was to compare overall academic achievement amongst all participants. Prior to the completion of the paired t-test, the data was tested for normal distribution using the Shapiro-Wilk test of normality. The pretest data was shown to be normally distributed with a significance of .50, which is greater than the alpha value of .05. The posttest data was also shown to be normally distributed with a significance value of .26 which is also greater than the alpha value of .05. Since the data was normally distributed, a paired t-test was used to compare the pretest data to the posttest data in SPSS. As shown in Table 3, it was found that there was a significant difference in academic achievement between the pretest and the posttest after the intervention with a significance value less than .001. On average, the posttest scores were 12.99 points higher than the pretest scores (95% CI [-19.75, -6.21]). The average score of the pretest was 72.96%, while the average score of the posttest was 85.95%.

Table 3 Academic Achievement Paired t-test

	Mean	Std. Deviation	Std. Error Mean	t	One-Sided p	Two-Sided p
Pretest	72.96	15.08	3.55			
Posttest	85.95	8.52	2.01			
Pretest-Posttest	-12.98	13.21	3.21	-4.05	<.001**	<.001**

$^*p < .05$, $^{**}p < .01$, N=18.

As part of this first research question, the researcher also analyzed different subgroups within the study. Students within different grade levels were compared to determine if a specific grade level (sixth, seventh, or eighth) would benefit most from DGBL. This study consisted of nine sixth-grade students, seven seventh-grade students, and two eighth-grade students. Due to the small sample size of eighth-grade students, a nonparametric test was used to compare students within different grade levels in SPSS. As shown in Table 4, a Kruskal-Wallis Test determined that there was no significant difference between grade levels since the significance level was .98 so the null hypothesis could be retained. The median amount between grade levels is most likely equal among the groups. This demonstrated that students in all grade levels, sixth, seventh, and eighth, can benefit academically from DGBL, but there was no significant difference between middle school grade levels.

Table 4 Grade Level Academic Achievement Kruskal-Wallis Test

Test Statistic	$.05^{a,b}$
Degree of Freedom	2
Asymptotic Sig. (2-sided test)	.98

N=18.

[a] The test statistic is adjusted for ties.

[b] Multiple comparisons are not performed because the overall test does not show significant differences across samples.

The researcher then analyzed subgroups based on their current mathematics placement. There were three categories of mathematics placement: B, C, and Accelerated. These classifications were determined by the school, students, and parents based on student mathematics performance throughout the years and on standardized tests. In this sample, there were three B-level students, eight C-level students, and seven Accelerated students. As shown in Table 5, the Kruskal-Wallis Test, a nonparametric test, was used in SPSS due to the small sample of B-level students. There was no significant difference between students in varying levels of mathematics courses due to the significance level of .95 so the null hypothesis can be retained. The median amount between mathematics levels was most likely equal among the groups, which demonstrated that students in all mathematics levels, B, C, and Accelerated, can benefit academically from DGBL.

Table 5 Math Level Academic Achievement Kruskal-Wallis Test

Test Statistic	$.10^{a,b}$
Degree of Freedom	2
Asymptotic Sig. (2-sided test)	.95

N=18.

[a] The test statistic is adjusted for ties.

[b] Multiple comparisons are not performed because the overall test does not show significant differences across samples.

Based on the paired t-test, it was shown that there was a statistically significant improvement from pretest to posttest in academic achievement after the ten-week DGBL intervention. However, when analyzing the pretest and posttest results using a Kruskal-Wallis Test, based on grade levels and mathematics placement levels, there was not a statistically significant difference. These findings were consistent with those of several other researchers who analyzed data using DGBL within mathematics (Siew, 2018; Ke, 2019; Yang et al., 2018; Vandercruysse et al., 2017).

Prior Engagement and Academic Achievement

The second research question, "Is there a relationship between students' prior engagement and their academic achievement after utilizing DGBL in a middle school mathematics setting?" was analyzed using a multiple linear regression test in SPSS. This test was used to determine the relationship between academic achievement and students' prior engagement. Students' academic achievement was obtained through the pretest and posttest and the students' prior engagement was obtained through the modified NSSE. The difference between these two scores was used to establish students' academic achievement, along with the students' prior engagement scores based on the four engagement themes of academic challenge, learning with peers, experiences with faculty, and campus environment.

To determine students' prior engagement, the data was collected through the modified NSSE questionnaire. The modified NSSE questionnaire was scored according to the method developed by the Center for Postsecondary Research at Indiana University School of Education. All sixty-six questions correlated to one of the four engagement themes: academic challenge, learning with peers, experiences with faculty, or campus environment.

Each engagement theme question was converted from the Likert scale with four options to a sixty-point scale. For example, responses that were originally never, sometimes, often, or very often were recorded as 0, 20, 40, or 60. A student who chose the lowest response would receive a score of 0, while a student who chose the highest response would receive a score of 60. The survey options were changed from the word choices to the numbered scores to find the mean for each engagement theme for each participant. By having a mean score for each engagement theme, the researcher was then able to input the information into SPSS to complete other statistical analyses on the data. All sixty-six questions were then sorted according to the engagement theme. The values were then averaged together for each of the engagement themes. A mean was calculated for each student to give each student a final score for academic challenge, learning with peers, experiences with faculty, and campus environment. All of these calculations were completed in Microsoft Excel to prepare the data to be imputed into SPSS.

As shown in Table 6, a multiple linear regression test showed that there was no statistical significance between students' prior engagement based on the four engagement themes of academic challenge, learning with peers, experiences with faculty, and campus environment and academic achievement. Academic achievement (pretest to posttest) was compared with each of the four engagement themes (academic challenge, learning with peers, experiences with faculty, and campus environment). This demonstrates that students' prior engagement is not related to their academic achievement.

As a prerequisite to the multiple linear regression, correlations were also analyzed. There was a weak negative correlation between academic achievement and the engagement theme of academic challenge due to a correlational coefficient of -.12 and a .32 p-value, which demonstrated that there was not a statistically significant relationship between academic achievement and academic challenge. When analyzing academic achievement and the engagement theme of learning with peers, there was a weak positive correlation with a correlational coefficient of .16 and a .26 p-value. There was not a statistically significant relationship between academic achievement and learning with peers.

There was a weak positive correlation between academic achievement and the engagement themes of experiences with faculty and campus environment. When analyzing the engagement theme of experiences with faculty and academic achievement, the correlational coefficient of .04 and a p-value of .42, showed that there was not a statistically significant relationship. When analyzing the engagement theme of campus environment and academic achievement, the correlational coefficient of .04 and a p-value of .44, showed that there was not a statistically significant relationship.

Table 6 Academic Achievement and Engagement Themes

Variable	Academic Achievement	Academic Challenge	Learning with Peers	Experiences with Faculty
Academic Challenge	-.12			
Learning with Peers	.16	.54**		
Experiences with Faculty	.04	.83**	.92**	
Campus Environment	.04	.68**	.59**	.72**

*$p < .05$, **$p < .01$, N=18.

However, there was a statistically significant relationship among the four engagement themes: academic challenge, learning with peers, experiences with faculty, and campus environment. All p-values were less than .01 which indicated a statistically significant relationship. This demonstrates that these engagement themes are significantly related to one another and are a good indicator of students' prior engagement which helps strengthen the validity of the NSSE, but that a students' prior engagement score is not significantly related to how well they perform academically after the DGBL intervention.

The strongest correlations were with learning with peers and experiences with faculty as well as academic challenges and experiences with faculty. There was a very strong positive correlation between learning with peers and experience with faculty with a correlational coefficient of .92 and a p-value of .00. There was also a very strong positive correlation between academic challenge and experiences with faculty with a correlational coefficient of .83 and a p-value of .00.

Phase II Analysis

In the second phase of the data collection, the researcher administered a qualitative survey to the participants. The survey consisted of ten open-ended questions to determine students' motivation based on autonomy, competence, and relatedness. These questions were based on the quantitative surveys provided by the Center for Self-Determination Theory (CSDT), but were converted to qualitative questions. The survey was collected through a Google Form, which was then converted to a Google Sheet to be imported into NVivo.

Motivation

People's lives and experiences are complicated, and a variety of circumstances might impact their decisions and choices. People have complicated intentions that are intertwined with the intentions and actions of others. Researchers are in a unique position to describe and comprehend these intentions and behaviors. Researchers can connect explanations provided by the individuals that are being studied with explanations developed by the researchers to assist in answering the why question (Miles et al., 2020). Naturally, because there are so many possible causal explanations, the results are provisional and liable to change (Maxwell, 2012).

The third research question, "How does the students' motivation, based on autonomy, competence, and relatedness, help explain students' academic achievement and engagement with the use of DGBL?" involved analyzing the quantitative and qualitative data. After the intervention and the completion of the posttest, the students completed an open-ended survey that consisted of ten questions to help determine the students' motivation for DGBL to explain the quantitative results (Appendix E). The questions in this survey were based on students' motivational factors of autonomy, competence, and relatedness as identified by the SDT.

NVivo was used to store, code, and run queries on the data. Coding is a cyclical process that allows for different categories, themes, or concepts to emerge from qualitative data. Codes can be used to group and categorize similar sets of data, which can help the researcher organize and group the information to help answer research questions (Miles et al., 2020).

First Cycle Coding

To help answer the third research question during the first cycle of coding, structural coding was used with the predetermined themes of autonomy, competence, and relatedness. Structural Coding was utilized to apply a predetermined set of codes to the material based on the research question used to frame the survey questions (MacQueen et al., 2008). As shown in Table 7, the themes of autonomy, competence, and relatedness were used to gauge the students' motivation based on the self-determination theory.

Table 7 First Cycle Codebook

Code	Coding Description	Coded Quotes
Autonomy	The response involves a person's self-interests and values.	Student 16: "I could go to multiple worlds, fight the demon, or even build." Student 14: "There were quite a lot of choices, including which world you wanted to start with, what you wanted to do, what you wanted to complete, and more."
Competence	The response reports a feeling of assurance and effectiveness in action that comes from the desire and perseverance to overcome barriers and challenges in order to improve one's own abilities.	Student 1: "I am confident with using digital game-based learning in mathematics class because I can use what I learned in Prodigy in real life." Student 17: "It made it more fun, therefore, it helps me learn."
Relatedness	The response expresses a natural need to feel connected to people and the community and to have a sense of belonging.	Student 6: "I loved when I battled others anonymously, because it regained my sense of superiority." Student 5: "Creating an avatar in Prodigy helped me feel connected because it made me feel like I was in the game."

Information from the survey was coded to the theme of autonomy 64 times (40%). Data from the open-ended survey that related to a person's self-interests and values were coded to autonomy (Ryan & Deci, 2002). Student 16 stated, "I could go to multiple worlds, fight the demon, or even build" and Student 14 stated, "There were quite a lot of choices, including which world you wanted to start with, what you wanted to do, what you wanted to complete, and more". Both responses were coded to autonomy since they dealt with the choice and interests of the students.

Competence was coded 64 times (40%), which contained data related to a feeling of assurance and effectiveness in action that comes from the desire and perseverance to overcome barriers and challenges to improve one's own abilities (Ryan & Deci, 2002). Student 1 stated, "I am confident with using digital game-based learning in mathematics class because I can use what I learned in Prodigy in real life" and Student 17 stated, "it made it more fun, therefore, it helps me learn". These student responses were coded to competence because the statements were about students' self-confidence and willingness to overcome obstacles to improve their own performance.

Relatedness was coded 32 times (20%). These codes contained data where the students reported the need to feel connected to people and the community and to have a sense of belonging (Ryan & Deci, 2002). Student 6 stated, "I loved when I battled others anonymously, because it regained my sense of superiority" and Student 5 stated, "Creating an avatar in Prodigy helped me feel connected because it made me feel like I was in the game." Both of these quotes were coded to the theme of relatedness since the students were referring to the need to feel connected and have a sense of belonging.

Visual displays are often underutilized in qualitative research but are an integral part of the analysis process and are helpful to the reader to interpret the results (Scagnoli and Verdinelli, 2017; Verdinelli and Scagnoli, 2013). According to Miles et al. (2020) visual displays offer data in a logical and sometimes suggestive manner so that the viewer may draw conclusions and take appropriate action. Not only do these displays help the researcher and reader draw conclusions, but visual displays also “aid researchers assess, on a continual basis, the trustworthiness, credibility, dependability, confirmability, and/or transferability of the inferences made” (Onwuegbuzie & Dickinson, 2008). To help prepare the data for second cycle coding, word clouds were used to create visual displays with commonly used words. As shown in Figure 4, a visual display of a word cloud was created using the fifty most frequent words that were used in all of the survey responses. This word cloud was used to assist the researcher in identifying the most commonly used words throughout all of the open-ended surveys. As shown, there were some words that were expected such as game, prodigy, and math. However, there were other words that stood out such as satisfied, understand, new, avatar, and confident. These words were used to help narrow down the survey responses into three subcategories of autonomy, competence, and relatedness.

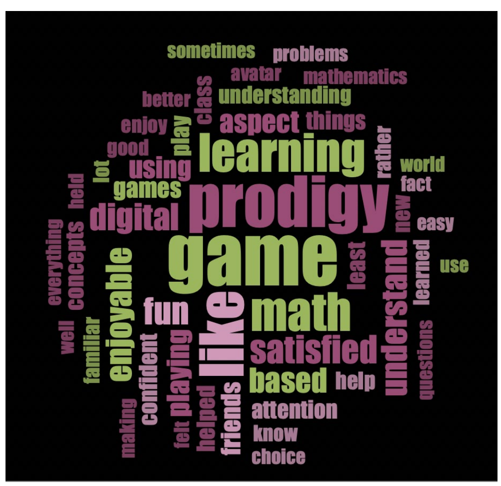

Figure 4 **Fifty Most Frequent Words**

To narrow down the codes of autonomy, competence, and relatedness, a word cloud was created for each of these themes. The researcher used the word clouds to help identify commonalities and differences among responses from the participants as well as to help prepare the data for second cycle coding (Miles et al., 2020). As shown in Figure 5, the word cloud for autonomy had a lot of the same most commonly used words, such as prodigy, game, and math, but there were also other words that stood out to help the researcher create child codes. Some of these keywords that were identified and then used to create codes were satisfied, choice, familiar, concepts, confident, and friends. These concepts relate to a person's self-interests and values (Ryan & Deci, 2002).

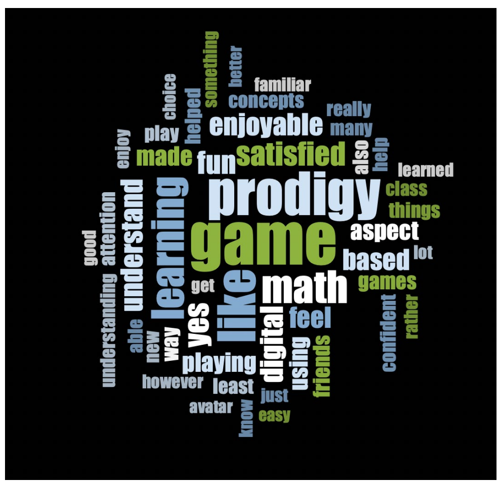

Figure 5 Autonomy Word Cloud

Figure 6 depicts the word cloud that was created for the data that was coded to the competence theme. Similar to the autonomy word cloud, there were overlapping words that were general terms such as Prodigy, game, and math. There were certain terms that were used to create child codes. Some of these keywords were confident, enjoyable, helped, and understand. These words align with the definition of competence that was used for this study, which describes competence as a feeling of assurance and effectiveness in action that comes from the desire and perseverance to overcome barriers and challenges in order to improve one's own abilities (Ryan & Deci, 2002).

Figure 6 Competence Word Cloud

As displayed in Figure 7, a word cloud was also created for the motivational factor of relatedness. Several words were predicted to appear, as they were in all of the word clouds. Relatedness refers to a need to feel connected and have a sense of belonging, especially to people and the community. Some keywords from this word cloud that helped the researcher create child codes were avatar, friends, choice, enjoyable, and learned.

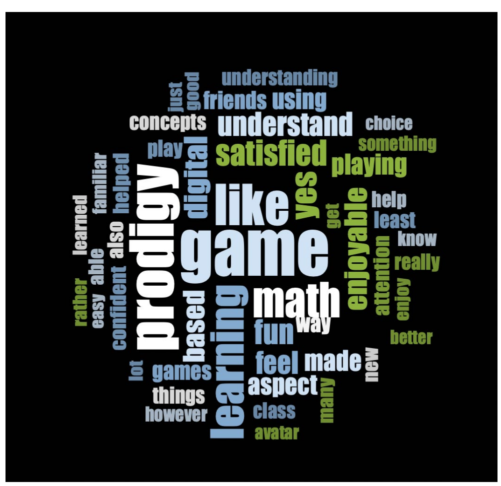

Figure 7 Relatedness Word Cloud

Second Cycle Coding

Once the first cycle coding was completed, the researcher began the second cycle coding to summarize the first cycle coding into reorganized and condensed themes. During this process, parent codes and child codes were created to group and categorize the codes appropriately (Gibbs, 2007). Qualitative research is an evolutionary journey where the researcher will expect various concepts to appear throughout the coding process, which may even change the direction of the research (Birks et al., 2008).

The codebook for the second-cycle coding is displayed in Table 8. As shown, the parent codes of autonomy, competence, and relatedness remained, however as the researcher explored the responses in more detail, child codes were also created. Within the autonomy parent code, themes of choice began to emerge from the data. For example, Student 7 stated, “There were much more choices than in other math games, I felt that I had more options to choose from when designing these differences made it appealing”. There were 22 sections of data coded to the child code of choice because the students described the choices that they experienced throughout the DGBL intervention. Another child code that emerged from the autonomy data was communication, which was when a student described communication throughout the game. For example, Student 1 expressed, “What I like about it is that I get to play online with friends”, so this information was coded to the communication child code. There were 7 sets of data that were coded to the child code of communication.

The parent code of competence was broken down into the three child codes of confidence, content, and performance. Information from the survey was coded to confidence if the student expressed confidence with DGBL, the mathematics content, or the game. For example, Student 16 stated, “I do enjoy and am confident with game-based learning. This makes me feel like it is fun instead of very serious work that must be done immediately.” Confidence was coded 10 times throughout the data. Data from the survey were coded to content when the student stated the mathematical content that they were exposed to. Student 9 stated, “It helped me understand probability” so this information was coded to content. There were 20 total sets of information coded to the child code of content. Finally, information was coded to the child code of performance when students self-reported their own performance with the game or with DGBL. Some examples of information that was coded to the child code of performance were when Student 9 stated, “I completely crushed the competition” and Student 7 reported, “I am quite satisfied with my performance, if I felt I could do better I could retry and try and get a better grade. I am quite satisfied with my level as well, considering I have never played prodigy before this year”. In total, there were 21 sets of data coded to performance.

Relatedness was separated into two child codes: avatar and familiarity. Information was coded to the child code of avatar when the student described their use and/or creation of an avatar within the game. For example, Student 14 stated, “Although I wasn’t too interested in the avatar aspect of Prodigy, I found it nice to see other people’s faces pop up on the screen, and made it feel more of a game with friends rather than just a generic math website. I also enjoyed the funny outfits that I could dress my character with, and the fact that certain clothes boosted your character.” There were 20 codes related to the child code of avatar. Data was coded to the child code of familiarity if the student explained their familiarity with either the game or the content that they were exposed to within the game. Familiarity was coded 16 times throughout the data. Student

10 stated, “I was familiar with the math concepts of surface area, geometry, and algebraic expressions. I was introduced to some new concepts”, so this information was coded to familiarity since the student expressed their familiarity with the content they were exposed to.

Table 8 Second Cycle Codebook

Code	Coding Description	Coded Quotes
Autonomy	The response involves a person's self-interests and values.	Student 16: "I could go to multiple worlds, fight the demon, or even build." Student 14: "There were quite a lot of choices, including which world you wanted to start with, what you wanted to do, what you wanted to complete, and more."
Choice	The student describes choice throughout the DGBL intervention.	Student 9: "I don't like how they only give you two tries for a question." Student 7: "There were much more choices than in other math games, I felt that I had more options to choose from when designing these differences made it appealing."
Communication	Communication within the game is described.	Student 1: "What I like about it is that I get to play online with friends." Student 9: "I get to communicate with other people."

Competence	The response reports a feeling of assurance and effectiveness in action that comes from the desire and perseverance to overcome barriers and challenges in order to improve one's own abilities.	Student 1: “I am confident with using digital game-based learning in mathematics class because I can use what I learned in Prodigy in real life.” Student 17: “It made it more fun, therefore, it helps me learn.”
Confidence	The student expresses their confidence with using DGBL, with the mathematics content, or confidence within the game.	Student 5: “I am confident with using digital game-based learning in a mathematics class.” Student 16: “I do enjoy and am confident with game-based learning. This makes me feel like it is fun instead of very serious work that must be done immediately.”
Content	The student stated content that they were exposed to during DGBL.	Student 9: “It helped me understand probability.” Student 2: “It helps me with my understanding of math because I can use what I learned so that I can use it in real math classes.”

Performance	The students self-reported their performance within the game or with DGBL.	Student 9: "I completely crushed the competition." Student 7: "I am quite satisfied with my performance, if I felt I could do better I could retry and try and get a better grade. I am quite satisfied with my level as well, considering I have never played prodigy before this year."
Relatedness	The response expresses a natural need to feel connected to people and the community and to have a sense of belonging.	Student 6: "I loved when I battled others anonymously, because it regained my sense of superiority." Student 5: "Creating an avatar in Prodigy helped me feel connected because it made me feel like I was in the game."
Avatar	The student described their use and/or creation of an avatar within the game.	Student 17: "I felt like I can create a cool avatar to show off to my friends." Student 14: "Although I wasn't too interested in the avatar aspect of Prodigy, I found it nice to see other people's faces pop up on the screen, and made it feel more of a game with friends rather than just a generic math website. I also enjoyed the funny outfits that I could dress my character with, and the fact that certain clothes boosted you're character."

Familiarity	The student explained their familiarity with either the game or the content that they were exposed to within the game.	Student 7: "I knew most of it. I was introduced to some new information, especially in the beginning where we were taking a test, but most of the content, I know now, only a few I do not know." Student 10: "Surface area, geometry, algebraic expressions. I was introduced to some new concepts."

As shown in Table 9, each of the child codes was created for each of the parent codes of autonomy, competence, and relatedness. The child codes of choice and communication were created under the parent code of autonomy. Choice was coded 22 times (19%) and communication was coded 7 times (6%). Performance, content, and confidence were created as child codes to the parent code of competence. Performance was coded 21 times (18%), content was coded 20 times (17%), and confidence was coded 10 times (9%). The child codes of avatar and familiarity were created under the parent code of relatedness. Avatar was coded 20 times (17%) and familiarity was coded 16 times (14%).

Table 9 Frequency and Percentage Table of Motivation

Autonomy		Competence			Relatedness	
Choice	Communication	Performance	Content	Confidence	Avatar	Familiarity
22 (19%)	7 (6%)	21 (18%)	20 (17%)	10 (9%)	20 (17%)	16 (14%)

Combined Results

To determine if there was a relationship between student motivation, academic achievement, and prior engagement, the researcher had to merge the quantitative data and the qualitative data. To merge the data, the researcher met with two other middle school teachers to analyze the survey data further using inter-rater reliability (Lim et al., 2012). Each teacher was briefed on the study as well as the meanings and definitions of autonomy, competence, and relatedness as they related to the current study. In the first cycle of coding of the qualitative data, each question was coded to one of the motivational factors of autonomy, competence, or relatedness. The researcher demonstrated how each teacher was going to independently score each of the ten questions for all eighteen students on a Likert scale of 1-5; 1 representing Strongly Disagree and 5 representing Strongly Agree. For example, question 1 was, “Are you confident using digital game-based learning in a mathematics class? If so, what aspects of digital game-based learning were you the most satisfied with?”. This was a question that was coded to the competence motivational factor. In the analysis of the responses, the teachers had to rate the student responses based on 1 representing that they strongly disagree that the students' response shows competence, 2 representing that the teacher disagrees that the students' response shows competence, 3 representing that the teacher is undecided that the students' response shows competence, 4 representing that the teacher agrees that the students' response shows competence, and 5 representing that the teacher strongly agrees that the students' response shows competence.

The teachers and the researcher independently scored each of the students' motivation responses on a scale of 1-5. The same three teachers, the researcher and two others, all scored each of the ten questions for each of the eighteen students to utilize a fully crossed design (Hallgren, 2012). This data was then averaged to develop one final score per student, per question. Most of the questions were scored similarly or with slight variations, but there were some questions with greater variations in ratings. For example, as shown in Table 10, most scores for Student 2 were consistent among all 3 raters, however the scores for question 8 showed some inconsistency. Rater 1 scored the response as a 5, rater 2 scored the response as a 2, and rater 3 scored the response as a 3.

Table 10 Student 2 Ratings

	Rater 1	Rater 2	Rater 3
Question 1	5	5	5
Question 2	5	5	5
Question 3	5	3	4
Question 4	5	5	5
Question 5	5	4	4
Question 6	1	3	2
Question 7	1	3	2
Question 8	5	2	3
Question 9	3	5	4
Question 10	5	4	4

To help alleviate any variations, each of the students' scores were averaged together to give each question a final score. The questions were then sorted according to autonomy, competence, and relatedness. Autonomy was represented by questions 6, 7, 8, and 10, competence was represented by questions 1, 2, 5, and 9, and relatedness was represented by questions 3 and 4. As shown in Table 11, once the students' scores were sorted according to the motivational factor, then a mean was found for each category so that each student had one final score for autonomy, competence, and relatedness.

Table 11 Motivational Means

ID	Autonomy	Competence	Relatedness
1	5	4.7	4.7
2	2.9	4.6	4.5
3	3.2	3.9	4.2
4	2.9	4.2	4.7
5	2.4	4.5	4.5
6	4.8	5	4.7
7	4.8	3.9	4.3
8	3.1	4.7	3.8
9	3.9	4.7	4.5
10	2.9	3.4	1.5
11	4.3	3.9	4.2
12	3.8	4.7	3.8
13	1.3	1.5	1.5
14	4.2	4.5	1.8
15	3.6	3.8	3.5
16	3.7	4.9	4.2
17	4.8	4.9	5
18	4.2	4.7	4

A Pearson's correlation test was run using SPSS to compare the four engagement themes (academic challenge, learning with peers, experiences with faculty, and campus environment) to academic achievement, as well as motivation, based on autonomy, competence, and relatedness. As shown in Table 12, there was a correlation between relatedness and learning with peers, which suggested that students who indicated that they enjoy collaborative learning and discussion, as identified through the modified NSSE survey, also are motivated while utilizing DGBL due to a sense of connectedness to the people and community through DGBL. There was a positive statistical correlation between the engagement theme of learning with peers and the motivational factor of relatedness with a correlational coefficient of .56 and a p-value of .02.

This was further supported by the students' responses through the motivation survey where student 7 responded that creating an avatar in Prodigy "made it interactive and fun, it wasn't a single player game and I felt that I had a purpose to accomplishing something in the game" and student 17 stated "using and creating my avatar in Prodigy made me feel like I was in a real game". Both of these students acknowledged that creating an avatar within the game allowed them to feel a sense of connectedness to the other players while participating in collaborative learning. Furthermore, student 11 stated that Prodigy felt "like I was playing a normal video game with my friends" and student 6 stated "it was fun seeing other players without a sense of who they were". These responses reinforced that students are motivated while using DGBL due to their sense of belonging while learning with their peers.

Table 12 Correlations Between Engagement, Academic Achievement and Motivation

Variable	Academic Challenge	Learning with Peers	Experiences with Faculty	Campus Environment	Academic Achievement	Autonomy	Competence
Learning with Peers	.54*						
Experiences with Faculty	.83**	.92**					
Campus Environment	.68**	.59**	.72**				
Academic Achievement	-.12	.16	.05	.04			
Autonomy	.10	.31	.25	.02	.25		
Competence	.18	.37	.33	.18	.09	.64**	
Relatedness	.24	.56*	.48*	.37	.09	.47	.67**

*p < .05, **p < .01., N=18

There was also a strong positive correlation between relatedness and experiences with faculty. There was a moderate positive relationship between the engagement theme of experiences with faculty and the motivational factor of relatedness, with a correlational coefficient of .48 and a statistically significant p-value of .04. This could indicate that students who specified on the modified NSSE survey that they often interact and have discussions with their teachers also are motivated by a sense of connectedness and belonging through DGBL.

To further support the relationship between relatedness and experiences with faculty, the responses to the motivational survey were also further analyzed. Based on the student responses, it was shown that students are motivated by the avatar and community aspect of DGBL. Student 14 stated “I found it nice to see other people’s faces pop up on the screen, and made it feel more of a game with friends rather than just a generic math website. I also enjoyed the funny outfits that I could dress my character with, and the fact that certain clothes boosted your character” and student 5 expressed that “Creating an avatar in Prodigy helped me feel connected because it made me feel like I was in the game”. These responses further supported the correlation between relatedness and experiences with faculty by students expressing a sense of connectedness and belonging through DGBL. Student 17 also stated “I enjoy being able to do math while playing games, but I would want to have a teacher in front of me to answer my questions and struggles when learning a new topic”, which emphasized the desire to have a teacher connection while utilizing DGBL. There was found to be no statistical correlation between any of the other variables since all p-values were greater than .05. This could indicate that relatedness is a characteristic of DGBL that needs to be explored more.

Chapter 4 Summary

The results of the pretest, posttest, modified NSSE, and motivation survey were analyzed in this chapter. The explanatory sequential mixed methods design allowed for the quantitative data to be collected and analyzed, followed by the qualitative data to help clarify the results. During the first phase of the data analysis, the researcher analyzed students' academic achievement using a paired t-test to show that there was a significant difference from pretest to posttest. A Kruskal-Wallis Test was then used to analyze the subgroups of students within different grade levels as well as within different mathematics placement levels. Both of these tests showed that there was not a statistically significant difference.

The prior engagement data, based on the modified NSSE survey, was then analyzed to determine if there was a relationship between prior engagement and academic achievement. A multiple linear regression test was used and showed that there was no statistical significance between students' prior engagement, based on the four engagement themes, and academic achievement.

During phase two of the data analysis, the qualitative data collected from the motivation survey was first analyzed with first cycle and second cycle coding. Visual displays were also used to assist in this process. The results of the survey were then integrated with the quantitative data to determine if there was a relationship between student motivation, academic achievement, and engagement. To merge all of the data, the researcher used inter-rater reliability to score the open-ended questions with the assistance of two co-workers. A Pearson's correlation test was then run using the modified NSSE data, the pretest/posttest, and the motivation survey data. There was found to be a correlation between relatedness and experiences with faculty as well as learning with peers. In the following chapter, the discussions and conclusions of the research will be addressed.

CHAPTER FIVE: DISCUSSION AND CONCLUSION

Introduction

The goal of this explanatory sequential mixed methods study was to determine how prior engagement influences academic achievement and to analyze students' motivation for utilizing DGBL in mathematics based on autonomy, competence, and relatedness. A total of eighteen middle school students in grades six through eight took part in this study. Quantitative data was obtained first, which consisted of a pretest, posttest, and the modified NSSE survey, followed by qualitative data, which consisted of an open-ended survey.

In this chapter, the results of the study are discussed further, along with limitations and recommendations for future research. This will allow for further discussion regarding the integration of DGBL into middle school mathematics classrooms.

Discussion of Findings

Research question one was used to determine how DGBL affected students' academic achievement in mathematics. It was found that after the ten-week intervention, there was a significant difference in the scores from pretest to posttest. This was determined by analyzing the pretest and posttest scores through a paired t-test. These results were consistent with the findings of several researchers who studied DGBL within mathematics (Siew, 2018; Ke, 2019; Yang et al., 2018; Vandercruysse et al., 2017). For instance, Kao et al. (2017) found that DGBL allowed students to make connections with their prior knowledge and experiences to make the learning process more meaningful for all students; this, in turn, increased academic achievement. The current study used the DGBL program Prodigy, which differentiated the learning for each of the students to help the students find connections with their prior knowledge. This helped bridge the learning gap and increased academic achievement for students within the intervention.

Specifically, within mathematics, it was found that when DGBL infused progressive prompting strategies within the game, such as hints or guidance, it was found that students' academic achievement was increased and students were more likely to read all the questions and problems thoroughly (Yang et al., 2018). Prodigy permitted for progressive prompting within the game, which allowed the students to complete work at their own pace while following the game's narrative. Prodigy is an intrinsic DGBL environment, meaning that the mathematics content was integrated directly into the game, which contrasted with Vandercruysse et al. (2017) findings that extrinsically motivated DGBL improves students' academic achievement. However, Vandercruysse et al. (2017) did find that all students using DGBL, intrinsically motivated or extrinsically motivated, improved from pretest to posttest. The results of the paired t-test were also consistent with Naik (2017) who found that DGBL supports student learning and enhances the quality of the learning experience for higher education mathematics students. The current study also analyzed academic achievement based on grade level and mathematics placement level.

Within the first research question, the researcher also narrowed the data to different subgroups based on the students' grade level and mathematics placement level. When analyzing this information through Kruskal-Wallis tests, there was found to be no significant difference between grade levels or mathematics levels. These results would indicate that students in all grade levels and mathematics placement levels could benefit academically from the DGBL intervention in mathematics. Yang et al. (2018) and Chen and Hwang (2017) both had similar findings when it was identified that both low-achieving and high-achieving students can benefit academically from DGBL. The achievement gap was able to be bridged for the lower-achieving students since the content was able to be differentiated and scaffolded. While the high-achieving students were provided with challenges, which provided an improvement in academic achievement for students of all levels.

The second research question was used to analyze the relationship between students' prior engagement, as identified by the modified NSSE survey, and their academic achievement, which was determined by the pretest and posttest, after utilizing DGBL. The current study was particularly different from previous research because it analyzed students' prior engagement in school and throughout all of their classes. Identifying students' prior engagement was particularly important to this study to help identify aspects of the students' experiences inside and outside of the classroom to determine if there was any relationship between their prior engagement, based on the four engagement themes of academic challenge, learning with peers, experiences with faculty, and campus environment with academic achievement.

To analyze this data, the researcher used a multiple linear regression test, which showed that there was no relationship between academic achievement and students' prior engagement. Students' prior engagement does not significantly predict students' academic achievement while utilizing DGBL. From these results, it seems that there is no relationship between students' prior engagement in and around school and their academic growth after utilizing DGBL. Students' prior engagement themes and engagement levels were not related to their academic achievement.

Students' prior engagement levels were determined by the modified NSSE survey, which is designed to help colleges and universities identify the level of student participation and engagement. These results were contrary to results that analyzed student engagement during game-play. For example, Mikropoulos and Natsis (2011) found that when students were engaged in DGBL, they developed other skills such as reflective practices that could be applied through academic content and real-world applications. Chen et al. (2017) had similar findings that DGBL improved students' awareness of their teamwork and communication skills, as well as their efficacy, which were skills that were transferable to other areas of academia. A possible reason for this disparity could be that engagement has been shown to increase during DGBL but utilizing DGBL does not have an effect on the level of student participation and engagement in and around the school at other times (Hamari et al., 2016; Ronimus et al., 2019; Hsieh et al., 2015; Ke et al., 2016).

The final research question used both quantitative and qualitative data to analyze how the students' motivation, based on autonomy, competence, and relatedness, helped explain students' academic achievement and prior engagement based on academic challenge, learning with peers, experiences with faculty, and campus environment. According to Ryan and Deci (2002), together autonomy, competence, and relatedness offer a safe space for people to pursue their passions, take on new challenges, learn new viewpoints, and actively transform cultural norms. A Pearson's correlation test showed that there was a correlation between the motivational factor of relatedness and the engagement theme of learning with peers.

Relatedness refers to the innate need to be connected with others through a sense of community and togetherness. These results may imply that students who participate in collaborative learning and discussion, as determined by the modified NSSE survey, are also motivated when using DGBL because of a sense of connectivity to the people and community. These results were consistent with Rogers (2017) who found that when a digital game contained characters and a plot, it satisfied relatedness. When a game had a positive impact on relatedness, it was more enjoyable to play (Rogers, 2017).

Prodigy offered students a sense of connectedness by allowing for communication between other students. It was evident that students' felt a sense of connectedness while playing the game by several of their responses to the survey. Students reported that they enjoyed being able to battle others anonymously, creating an avatar made them feel like they were a part of the game, and they found it exciting to be able to see other people's avatars as they interacted throughout the game. The students created their own wizard avatar and battled other students or the computer. Throughout the game, they also traveled through different worlds where they could chat with other students and challenge other students on mathematics topics. These peer-to-peer interactions, along with the self-created avatars, allowed for students to feel a sense of community and togetherness, which explains why students who participate in collaborative learning and discussion are motivated by a sense of relatedness within the game.

There was also a strong correlation between relatedness and experiences with faculty. This might imply that students who indicated on the modified NSSE survey that they frequently communicate with and discuss their teachers are also driven by DGBL's sense of closeness and belonging. Chen and Law (2016) also found that students' learning performance was increased when there was teacher-provided feedback and scaffolds. Since the NSSE survey was evaluating students' prior engagement within the school, and there was a correlation with relatedness, this was consistent with Barzilai and Blau (2014) who stated that teacher feedback should be provided before and during DGBL for the feedback to be the most effective. Through the open-ended survey, the students reported that they understood the expectations of the game and that the game had a clear purpose. Many researchers focused on feedback from teachers during DGBL, however the results of this study were consistent with Barzilai and Blau (2014) that the feedback should be provided before and during DGBL to build the relationship between relatedness and experiences with faculty.

Implications

The results of this study could have several implications on the educational system. The main implication is the implementation of DGBL within mathematics classrooms and curricula. The findings of this study showed that middle school mathematics students with varying grade-levels and mathematics levels could benefit academically from implementing DGBL. In this study, the DGBL platform Prodigy was used for one hour, once per week and on average, students' scores from pretest to posttest increased 12.99 points. From pretest to posttest, there was a significant difference in academic achievement, as identified through the paired t-test.

Due to these results, middle school mathematics teachers and school districts should consider including DGBL as part of their weekly routine to increase academic achievement in mathematics. Since DGBL allows for easy differentiation, it may be used to scaffold learning for lower-achieving students to close the achievement gap and improve learning achievement, as well as providing challenges for high-achieving students. (Yang et al., 2018; Chen and Hwang, 2017). Students in B, C, and Accelerated mathematics classes all benefited from the DGBL, which is why it should be implemented in all mathematics classes throughout middle school.

Another implication from the results of this study could be the choice of game that the school districts decide to implement. There is a greater chance for better academic accomplishment if pupils are more stimulated by and drawn to DGBL. (Hung et al., 2014). Every school district has a different population of students with varying needs. However, there are many options for different DGBL platforms that can include varying options for students, districts, and teachers. DGBL must provide appropriate content while also being adaptable enough to meet the needs of learners. (Yang et al., 2017).

There was no correlation between students' prior engagement and their academic achievement after utilizing DGBL. However, there was found to be a correlation among the engagement themes of academic challenge, learning with peers, experiences with faculty, and campus environment. This solidified the validity of the NSSE. School districts may be interested in utilizing some type of prior engagement survey to help identify how much time students put into their own education and how the school establishes its resources, curriculum, and learning opportunities to attain student engagement (Ewell & McCormick, 2020). The results of this survey can be used throughout the school to identify students or groups of students who can benefit from a more engaged environment.

Based on the open-ended surveys, students showed their motivation for DGBL through the areas of competence, relatedness, and autonomy. Most students responded positively to the open-ended questions, but did indicate that some of the content they were exposed to was mostly review topics. This could help teachers implement DGBL as a review tool instead of a teaching tool. DGBL can be used for independent or group practice of a skill that was previously taught within the mathematics class.

It was also determined that there was a correlation with the motivational factor of relatedness. This must be another aspect that educators and school districts analyze when choosing a DGBL program that is appropriate for their population. Games should be chosen that allow for students to feel a sense of connectedness to the community and have a sense of belonging. This could be implemented through the use of avatars, characters, a plot, and interactions between players (Rogers, 2017; Ryan et al., 2006). By helping students to create connections between existing information and experiences and new knowledge and experiences, DGBL makes learning more relevant and tangible for students (Ke et al., 2017). Students can use DGBL to develop their communication and problem-solving skills, as well as teamwork and group goals (Shihl & Hsu, 2016).

Limitations

There were several limitations to the current study that should be noted. As stated earlier, the main limitation of any mixed methods research is the time it takes to collect and analyze the data, especially when there is only one researcher (Creswell, 2014; Ivankova et al., 2006). In this study, the researcher was collecting data from a questionnaire, a pretest and posttest, and a survey. This was an extensive amount of information to collect, organize, and examine. The questionnaire, pretest, and posttest were quantitative data sets, and the motivation survey was qualitative data. To successfully analyze all of this data, the researcher had to be comfortable and familiar with the methods used for both data sets.

Another limitation of explanatory sequential research was the validity of the findings. The qualitative data was used to help expand on the quantitative results, however, due to the amount of data collected, researchers often overlook some aspects of the quantitative results which could use further explanation (Creswell, 2014). To alleviate some of these concerns, the researcher chose and modified the instruments used in this study that have been tested and evaluated (Zohrabi, 2013). The questionnaire was modified from an already created questionnaire by experts in the field. The pretest and posttest were created by the researcher from questions in the Big Ideas Math program, which is backed by theories and curriculum experts. The survey was created by the researcher with guidance from the questionnaires provided by the Center for Self-Determination Theory.

The results of the study vary depending on the students' perceptions of the game. During this research, the students only be played one game, Prodigy. Since there were not several mathematics games, there may be some students who did not like specific aspects of the game but may be inclined to use other DGBL tools.

Since this study involved minors, the researcher needed to receive parental consent prior to the start of the study. This did eliminate some potential participants whose data could not be included in the study. However, these students did still participate in the after-school program. Only the students who consented to participate were included in the study, which limited the total number of participants as well as the number of participants in each of the subgroups. There was a total of eighteen participants who were all in sixth, seventh, or eighth grade. Looking at the subgroups of participants according to grade level and mathematics placement level, those numbers were much smaller, which is why for certain statistical tests, only nonparametric tests were appropriate. There were nine sixth-grade students, seven seventh-grade students, and two eighth-grade students. Of these students, there were three B-level students, eight C-level students, and seven Accelerated students. In a middle school with about one thousand students, this represented less than two percent of the total student population. Another study with a larger population should be completed to confirm the results of the current study.

This study was completed as a voluntary after-school program. Most of the participants that volunteered for this study may have already had a previous interest or inquiry into mathematics or DGBL. For example, when analyzing the pretest data, the average score was 73%. This was not as low as the researcher had anticipated, which could mean that the students who participated in the study had some prior academic knowledge of the content that they were going to be exposed to. This was further solidified by some responses on the open-ended survey. For example, one student responded, “Prodigy helped me review what I learned in the past” and another student stated, “I was familiar with most of the concepts when playing Prodigy”. If this study was completed in a different setting, such as in class instead of an after-school program, the results may differ.

This study only used one DGBL program, Prodigy. Prodigy is a DGBL mathematics program suitable for students in first through eighth grades. It is an appropriate tool for the students to utilize, but there are several other options for games. The students may have benefited more from utilizing a variety of games instead of one game for ten weeks.

A final consideration of this study could be that students' academic achievement may have been improved from several factors, not only DGBL. For example, students' academic achievement could be attributed to participating in an extracurricular mathematics program, not necessarily DGBL. It could also be implied that academic achievement may have been improved regardless of any intervention due to time and maturity of the students.

Recommendations for Future Research

More research should be conducted with a larger sample size with careful attention to participants in particular subgroups. To get a larger sample size, a researcher may want to conduct the study within the classroom to determine how a larger sample size would respond to the DGBL intervention. By completing a study in this manner, there may be a greater variety of students with varying backgrounds and interests since all students are required to be enrolled in mathematics classes, but not all students may have a preference for mathematics.

Based on the results of research question three, more research should be completed on the impact of relatedness within DGBL, specifically concerning the engagement themes of learning with peers and experiences with faculty. Relatedness was defined as a natural need to feel connected to people and the community and to have a sense of belonging (Ryan & Deci, 2002). This could indicate that students who also appreciate collaborative learning and discussions and students who have interactions with their teachers are more motivated through a sense of relatedness within the game, but more research would be necessary to determine the extent of this correlation.

Finally, further research should be done on how teachers could implement DGBL to have the most positive effect on students. During this study, only one program was used for one hour per week in an after-school setting. Throughout the hour session, students were only involved in the after-school program, however in a traditional classroom setting this may not be possible. For example, a teacher may have students work on the program for twelve minutes per day to equate to one hour per week, which may produce different results.

Conclusion

Prior research has shown that learning performance may be enhanced by using DGBL since it gives students a platform to have a challenging, yet enjoyable experience, which can drive them to keep persevering through obstacles to improve their progress (Chen et al., 2016). Since DGBL allows for easy differentiation, it may be used to scaffold learning for lower-achieving students to close the achievement gap and improve learning accomplishment, as well as provide challenges for high-achieving students (Yang et al., 2018). According to Chen and Hwang (2017), DGBL was able to close the achievement gap between low-achieving and high-achieving pupils. The low-achieving students particularly benefited from implementing a “team competition-based gaming approach into ubiquitous learning activities" (p. 95). The efficacy of DGBL on mathematics academic achievement has received varied evaluations; nonetheless, it has been demonstrated to either retain competency or increase academic achievement (Siew, 2018; Yang et al., 2018; Vandercruysee et al., 2017; Watson-Huggins & Trotman, 2019; Hulse et al., 2019, Carr, 2012).

This study was able to add to the current literature by supporting the claims that DGBL can increase academic achievement in mathematics. However, the claim that lower-performing students benefited more from DGBL was refuted since there was no difference between lower-level mathematics students and higher-level mathematics students. All students can benefit academically from DGBL in a middle school mathematics setting.

There was no significant difference between prior engagement and academic achievement. According to these findings, there appears to be no link between students' earlier engagement in and around school and their academic achievement after using DGBL. Prior engagement themes and degrees of involvement among students have little bearing on their academic performance.

There was found to be a correlation between relatedness and learning with peers, as well as relatedness and experiences with faculty. Additional research should be conducted on the influence of relatedness within DGBL, especially in connection to the engagement themes of learning with peers and experiences with faculty. The results of this study might imply that students who like collaborative learning and conversations, as well as students who interact with their teachers, are more driven by a feeling of shared experience inside the game, but further study is needed to understand the degree of this link. Finally, additional studies into how teachers may utilize DGBL to have the most positive impact on pupils should be conducted.

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APPENDIX A

6th Grade Pretest/Posttest

1. Which number is equivalent to 5.139-2.64?

F. 2.499

G. 2.599

H. 3.519

I. 3.599

2. Which number is equivalent to $\frac{4}{9} \div \frac{5}{7}$?

A. $\frac{20}{63}$

B. $\frac{28}{45}$

C. $\frac{45}{28}$

D. $\frac{63}{20}$

3. Which number is a prime factor of 572?

A. 4

B. 7

C. 13

D. 22

4. What is the missing denominator in the expression below?

$$\frac{4}{8} \div \frac{2}{\square} = \frac{3}{4}$$

A. 1

B. 2

C. 3

D. 8

5. Which expression is equivalent to 5 x 5 x 5 x 5?

A. 5 x 4

B. 4^5

C. 5^4

D. 5^5

6. Which fraction is not equivalent to 25%?

F. $\frac{1}{4}$

G. $\frac{2}{5}$

H. $\frac{5}{20}$

I. $\frac{25}{100}$

7. Which percent is equivalent to $\frac{4}{5}$?

F. 20%

G. 45%

H. 80%

I. 125%

8. Which pair of numbers does not have a least common multiple less than 100?

A. 10, 15

B. 12, 16

C. 16, 18

D. 18, 24

9. Which number is equivalent to $\frac{5}{12}$ x $\frac{4}{9}$?

A. $\frac{5}{27}$

B. $\frac{3}{7}$

C. $\frac{15}{16}$

D. $\frac{5}{3}$

10. Which list of numbers is in order from least to greatest?

F. 0.8, $\frac{5}{8}$, 70%, 0.09

G. $\frac{5}{8}$, 70%, 0.8, 0.09

H. 0.09, $\frac{5}{8}$, 0.8, 70%

I. 0.09, $\frac{5}{8}$, 70%, 0.8

11. Which number is equivalent to 1.32 divided by 0.006?

A. 2.2

B. 22

C. 220

D. 2200

12. Which ratio is equivalent to 4:14?

F. 2:12

G. 10:35

H. 18:28

I. 8:18

13. Which number is equivalent to the expression below?

$6 \times 8 - 2 \times 3^2$

A. 12

B. 30

C. 323

D. 414

14. Which number is equivalent to 7059 divided by 301?

F. 23

G. $23 \frac{136}{7059}$

H. $23 \frac{136}{301}$

I. 136

15. A meteoroid moving at a constant speed travels 6 ⅞ miles in 30 seconds. How far does the meteoroid travel in 1 second?

F. $\frac{1}{5}$mile

G. $\frac{11}{48}$ mile

H. $2 \frac{7}{24}$ miles

I. $206 \frac{1}{4}$ miles

APPENDIX B

7th Grade Pretest/Posttest

1. A football team gains 2 yards on the first play, loses 5 yards on the second play, loses 3 yards on the third play, and gains 4 yards on the fourth play. What is the team's total gain or loss?

A. a gain of 14 yards

B. a gain of 2 yards

C. a loss of 2 yards

D. a loss of 14 yards

2. Which expression is not equivalent to 0?

F. 5-5

G. - 7+7

H. 6-(-6)

I. - 8-(-8)

3. What is the value of the expression?

$$|-2-(-2.5)|$$

A. -4.5

B. -0.5

C. 0.5

D. 4.5

4. What is the value of the expression when a=8, b=3, and c=6?

$$|a^2 - 2ac + 5b|$$

A. -65

B. -17

C. 17

D. 65

5. What number belongs in the box to make the equation true?

$$3\frac{1}{2} \div 5\frac{2}{3} = \frac{7}{2} \times \square$$

A. $\frac{3}{7}$

B. $\frac{3}{2}$

C. $\frac{17}{3}$

D. $\frac{13}{2}$

6. What is the value of the expression?

$$\frac{5.2 - 2.25}{0.05}$$

F. -346

G. 0.59

H. 5.9

I. 59

7. You leave school and walk 1.237 miles west. Your friend leaves school and walks 0.56 miles east. How far apart are you and your friend?

A. 0.677 mile

B. 0.69272 mile

C. 1.293 miles

D. 1.797 miles

8. Which expression represents a negative value?

F. $2 - |-7 + 3|$

G. $|-12 + 9|$

H. $|5| + |11|$

I. $|8 - 14|$

9. What is the value of -5+(-7)?

F. -12

G. -2

H. 2

I. 12

10. What is the value of $|a^2 - 2ac + 5b|$ when a=-2, b=3, and c=-5?

A. -9

B. -1

C. 1

D. 9

11. What is the value of -1 ½ - (-1 ¾)?

A. $-3\frac{1}{4}$

B. $\frac{1}{4}$

C. $\frac{6}{7}$

D. $2\frac{5}{8}$

12. What is the value of the expression when q=-2, r=-12, and s=8? $\frac{-q^2-r}{s}$

F. -2

G. -1

H. 1

I. 2

13. Which expression has the greatest value when x=-2 and y=-3?

F. -xy

G. xy

H. x-y

I. -x-y

14. Which expression has a negative value when x=-4 and y=2?

F. -x+y

G. y-x

H. x-y

I. -x-y

15. Which decimal is equivalent to 2/9?

F. 0.2

G. $0.\underline{2}$

H. 0.29

I. 0.5

APPENDIX C

8th Grade Pretest/Posttest

1. Which value of x makes the equation true? 4x=32

A. 8

B. 28

C. 36

D. 128

2. A taxi ride costs \$3 plus \$2 for each mile driven. You spend \$39 on a taxi. This can be modeled by the equation 2m+3=39, where m represents the number of miles driven. How long was your taxi ride?

F. 18 mi

G. 21 mi

H. 34 mi

I. 72 mi

3. Which of the following equations has exactly one solution?

A. $\frac{2}{3}(x+6) = \frac{2}{3}x + 4$

B. $\frac{3}{7}y + 13 = 13 - \frac{3}{7}y$

C. $\frac{4}{5}\left(n + \frac{1}{3}\right) = \frac{4}{5}n + \frac{1}{3}$

D. $\frac{7}{8}\left(2t + \frac{1}{8}\right) = \frac{7}{4}t$

4. The formula d=rt relates distance, rate, and time. Solve the formula for t.

F. t=dr

G. t=$\frac{d}{r}$

H. t=d-r

I. t=$\frac{r}{d}$

5. What is a possible first step to solve the equation 3x+5=2(x+7)?

A. Combine 3x and 5

B. Multiply x by 2 and 7 by 2

C. Subtract x from 3x

D. Subtract 5 from 7

6. In 10 years, your aunt will be 39 years old. Let m represent your aunt's age today.

Which equation can you use to find m?

F. m=39+10

G. m-10=39

H. m+10=39

I. 10m=39

7. Which value of y makes the equation 3y+8=7y+11 true?

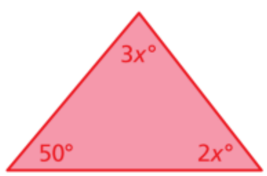
A. -4.75

B. -0.75

C. 0.75

D. 4.75

8. What is the greatest angle measure in the triangle?



Sum of angle measures: 180°

A. 26 degrees

B. 78 degrees

C. 108 degrees

D. 138 degrees

9. Which value of x makes the equation 6(x-3)=4x-7 true?

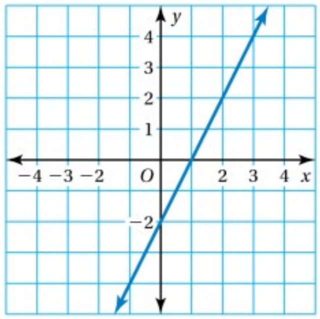
F. -5.5

G. -2

H. 1.1

I. 5.5

10. Which equation matches the line shown in the graph?



A. y=2x-2

B. y=2x+1

C. y=x-2

D. y=x+1

11. Which point lies on the graph of 6x-5y=14?

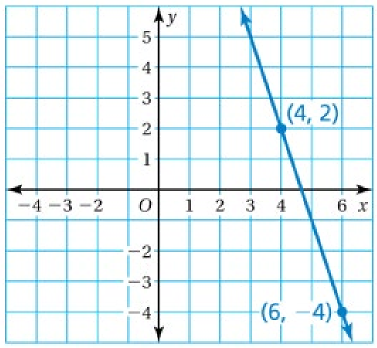
F. (-4, -1)

G. (-2, 4)

H. (-1, -4)

I. (4, -2)

12. Which of the following is the equation of a line parallel to the line shown in the graph?



F. y=3x-10

G. $y=\frac{1}{3}x+12$

H. y=-3x+5

I. $y=-\frac{1}{3}x-18$

13. An emergency plumber charges $49.00 plus $70.00 per hour of the repair. A bill to repair your sink is $241.50. This can be modeled by 70.00h+49.00=241.50, where h represents the number of hours for the repair. How many did it take to repair your sink?

A. 2.75 hours

B. 3.45 hours

C. 4.15 hours

D. 13,475 hours

14. Solve the formula K=3M-7 for M.

A. M=K+7

B. M=$\frac{K+7}{3}$

C. M=$\frac{K}{3}+7$

D. M= $\frac{K-7}{3}$

15. Which of the following is true about the graph of the linear equation y=-7x+5?

F. The slope is 5, the y-intercept is -7.

G. The slope is -5, the y-intercept is -7.

H. The slope is -7, and the y-intercept is -5.

I. The slope is -7, and the y-intercept is 5.

APPENDIX D

Modified NSSE Questionnaire

*This survey was given as a Google Form.

During the current school year, about how often have you done the following?

Response options: Very often, Often, Sometimes, Never

a. Asked questions or contributed to class discussions in other ways

b. Asked another student to help you understand class material

c. Explained class material to one or more students

d. Prepared for tests by discussing or working through class material with other students

e. Worked with other students on class projects or assignments

f. Given a class presentation

g. Combined ideas from different classes when completing assignments

h. Connected your learning to societal problems or issues

i. Examined the strengths and weaknesses of your own views on a topic or issue

j. Tried to better understand someone else's views by imagining how an issue looks from their perspective

k. Learned something that changed the way you understand an issue or concept

l. Connected ideas from your classes to your prior experiences and knowledge

m. Talked about career or future educational plans with a faculty member (teacher, guidance counselor, principal, etc.)

n. Worked with a faculty member on activities other than coursework (committees, student groups, clubs, etc.)

o. Discussed class topics, ideas, or concepts with a faculty member outside of class

p. Discussed your academic performance with a faculty member

During the current school year, about how often have you done the following?

Response options: Very often, Often, Sometimes, Never

a. Asked questions or contributed to class discussions in other ways

During the current school year, how much has your classes emphasized the following?

Response options: Very much, Often, Sometimes, Very little

a. Memorizing course material

b. Applying facts, theories, or methods to practical problems or new situations

c. Analyzing an idea, experience, or line of reasoning in depth by examining its parts

d. Evaluating a point of view, decision, or information source

e. Forming a new idea or understanding from various pieces of information

During the current school year, to what extent have your teachers done the following?

Response options: Very much, Often, Sometimes, Very little

a. Clearly explained class goals and requirements

b. Taught classes in an organized way

c. Used examples or illustrations to explain difficult points

d. Provided feedback on a draft or work in progress

e. Provided prompt and detailed feedback on tests or completed assignments

f. Explained in advance the criteria for successfully completing your assignments

g. Reviewed and summarized key ideas or concepts

h. Taught in a way that aligns with how you prefer to learn

i. Enabled you to demonstrate your learning through quizzes, assignments, and other activities

During the current school year, about how often have you done the following?

Response options: Very often, Often, Sometimes, Never

a. Reached conclusions based on your own analysis of numerical information (numbers, graphs, statistics, etc.)

b. Used numerical information to examine a real-world problem or issue (unemployment, climate change, public health, etc.)

c. Evaluated what others have concluded from numerical information

During the current school year, about how many papers, reports, or other writing tasks of the following lengths have you been assigned? (Include those not yet completed)

a. Up to 5 pages

b. Between 6 and 10 pages

c. 11 pages or more

During the current school year, about how often have you done the following?

Response options: Very often, Often, Sometimes, Never

a. Identified key information from reading assignments

b. Reviewed your notes after class

c. Summarized what you learned in class or from class materials

During the current school year, to what extent have your classes challenged you to do your best work?

Response options: 1=Not at all to 7=Very much

Indicate the quality of your interactions with the following people at your school.

Response options: 1=Poor to 7=Excellent

a. Students

b. Academic advisors (guidance counselors)

c. Teachers

d. Other administrative staff (principals, secretaries, etc.)

How much does your institution emphasize the following?

Response options: Very much, Often, Sometimes, Very little

a. Spending significant amounts of time studying and on academic work

b. Providing support to help students succeed academically

c. Using learning support services

d. Encouraging contact among students from different backgrounds (social, racial/ethnic, religious, etc.)

e. Providing opportunities to be involved socially

f. Providing support for your overall well-being (recreation, health care, counseling, etc.)

g. Helping you manage non-academic responsibilities (work, family, etc.)

h. Attending school activities and events (performing arts, athletic events, etc.)

i. Attending events that address important social, economic, or political issues

To what extent do you agree or disagree with the following statements?

Response options: Strongly agree, Agree, Disagree, Strongly Disagree

a. I feel comfortable being myself at my school.

b. I feel valued by my school.

c. I feel like part of the community at this school.

How much has your experience at this institution contributed to your knowledge, skills, and personal development in the following areas?

Response options: Very much, Quite a bit, Some, Very little

a. Writing clearly and effectively

b. Speaking clearly and effectively

c. Thinking critically and analytically

d. Analyzing numerical and statistical information

e. Acquiring job- or work-related knowledge and skills

f. Working effectively with others

g. Developing or clarifying a personal code of values and ethics

h. Understanding people of other backgrounds (economic, racial/ethnic, political, religious, nationality, etc.)

i. Solving complex real-world problems

j. Being an informed and active citizen

APPENDIX E

Open-Ended Survey Questions

1. Are you confident with using digital game-based learning in mathematics class? If so, what aspects of digital game-based learning were you the most satisfied with?
2. How did using Prodigy help you with your understanding of math?
3. Describe the math concepts you were familiar with while playing this game? Were you introduced to a lot of new content?
4. Describe how using and creating your avatar in Prodigy helped you feel a sense of connectedness to the game and the gaming community (ex: versing other players anonymously, exploring different worlds, etc.).
5. How satisfied are you with your performance throughout the game?
6. Within the game Prodigy, did you feel like there was a lot of choice? Were there different gaming features and options that appealed to you? If so, please describe them.
7. Why did you like/dislike using Prodigy? What aspects of the activity were the most enjoyable/least enjoyable?
8. Did Prodigy hold your attention while playing the game? If not, please explain.
9. After working with this activity, how would you describe your understanding of digital game-based learning?
10. What was the most enjoyable aspect of digital game-based learning? What was the least enjoyable aspect?