Spring 5-6-2024

The Effects of a Gamified Flipped Classroom on First-Generation Low Income Student Motivation and Achievement in a Georgia High School Mathematics Class

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doi: https://doi.org/10.57709/36975836

The Effects of a Gamified Flipped Classroom on First-Generation Low-Income Student Motivation and Achievement in a Georgia High School Mathematics Class

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A Thesis/Dissertation Submitted in Partial Fulfillment of the Requirements for the Degree of

Doctorate of Philosophy

in the College of Arts and Sciences

Georgia State University

2024

ABSTRACT

Math continues to be a challenge for American high school students. The United States was placed ninth in reading and thirty-first in math literacy out of 79 nations and economies in the most recent results for international exams given to teens. Math test results were worst in states with large wealth disparity. Motivation and engagement, conceptualized as students' energy and drive to participate, learn, work efficiently, and realize their potential at school, play a significant impact in students' academic success. While the flipped classroom methodology has demonstrated some success within helping this trend, many studies indicate that additional assistance is needed in keeping the students motivated and engaged for the technique to be successful. The purpose of this study was to help continue to examine supplementing the flipped classroom with additional support to further engage and motivate students. An experimental quantitative study compared a gamified flipped classroom instructional methodology to both a normal flipped classroom and a traditional lecture style class within a six-week summer program for low-income and first-generation high school students. Scores from a post-test assessment examined the differences in achievement. Motivation was measured through scores from the Math Motivation Questionnaire and engagement was measured through scores from the Student Engagement in Mathematics Scale. Findings could contribute to the literature revealing how gamification can assist in motivating and engaging high school students within a mathematics class. This study could have practical significance by identifying the effective features of both the flipped classroom and gamification within mathematics. This knowledge could be useful in determining best practices for designing and implementing this teaching technique.

INDEX WORDS: Gamification, Flipped Classroom, Mathematics, Motivation, Engagement, Achievement

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DEDICATION

This dissertation is dedicated to my family, friends, and colleagues who have walked this journey with me. First to my Lord and Savior, the source of my strength, wisdom, and unwavering belief. Without You, this journey would not have been possible. To my mom, Melusina S. Reeberg, you are my eternal inspiration and unwavering support system. You nurtured my curiosity from the very beginning, always believing in my potential and inspiring me to reach for the stars. This dissertation stands as a testament to your unwavering love and support, even during the most challenging moments. Your love, sacrifices, and belief in me have shaped me into the person I am today. I know you are smiling down from heaven as this journey of my academic career comes to completion. To my aunt, Marilynn Sasportas Robinson, whose kindness, and boundless encouragement have been a constant source of strength. Thank you for reminding me of the importance of perseverance and celebrating every milestone along the way. Your wisdom and encouragement have always illuminated my path. Your unwavering support has been a pillar in my life. Thank you for sharing me with your sister and loving me as your own. To my beloved family, whose unconditional love and support have carried me through every challenge. I am eternally grateful for your presence in my life. To my cherished friends and colleagues, who have shared both laughter and tears along this journey. Your companionship, insights, and encouragement have made this experience all the richer. And to my dearest wife, Sherontae Treva Maxwell, who has been my partner, confidante, and biggest cheerleader. Your untiring love, patience, and belief in me have been my guiding star. Your love, patience, and understanding have been the bedrock of my success. This dissertation reflects not only my hard work, but also the love and support that surrounded me. Thank you for being the light that guided me through the darkness and for always celebrating my achievements.

ACKNOWLEDGEMENTS

This journey culminating in this dissertation would not have been possible without the dedication and guidance of many individuals. First and foremost, I offer my deepest gratitude to my esteemed committee chair, Dr. Jonathan Cohen. Your insightful feedback, continued encouragement, and expertise have been invaluable throughout this process. Thank you for your patience, meticulous guidance, and for always believing in my potential. To the esteemed members of my committee, Drs. Miles Irving, Michael Law, and Lauren Margulieux, I am deeply grateful for your valuable time, insightful suggestions, and willingness to share your knowledge. Your diverse perspectives and expertise have significantly improved the quality of this work. I extend my heartfelt thanks to all the dedicated teachers who have shaped my academic journey. To my secondary school teachers, thank you for igniting my love for learning and fostering a foundation upon which I could build. To my professors at Morehouse College, Georgia Southern University, and Georgia State University, thank you for challenging me intellectually, expanding my knowledge, and inspiring me to pursue this endeavor. To each one of you, thank you from the bottom of my heart.

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LIST OF ABBREVIATIONS

Abbreviation	**Definition**
ANOVA	Analysis of Variance
AP	Action Points
FCM	Flipped Classroom Method
GP	Gold Pieces
HP	Heart Points
ICT	Information and Communication Technology
LMS	Learning Management System
MMQ	Math Motivation Questionnaire
MMQPEM	Math Motivation Questionnaire Post Extrinsic Motivation Construct
MMQPIM	Math Motivation Questionnaire Post Intrinsic Motivation Construct
MMQPLMA	Math Motivation Questionnaire Post Low Math Anxiety Construct
MMQPPR	Math Motivation Questionnaire Post Personal Relevance Construct
MMQPSD	Math Motivation Questionnaire Post Self Determination Construct
MMQPSE	Math Motivation Questionnaire Post Self Efficacy Construct
NAEP	National Assessment of Educational Progress

SDT	Self-Determination Theory
SEM	Student Engagement in Mathematics Scale
SEMPCOG	Student Engagement in Mathematics Scale Cognitive Engagement Sub Measure
SEMPEM	Student Engagement in Mathematics Scale Emotional Engagement Sub Measure
SEMPSOC	Student Engagement in Mathematics Scale Social Engagement Sub Measure
USED	U.S. Department of Education
XP	Experience Points

PREFACE

CHAPTER 1. INTRODUCTION

The proposed research study will determine if the flipped classroom instructional methodology combined with gamification elements will increase student motivation and achievement in Mathematics among low-income secondary-level students. An avalanche of technology resources has filled today's classrooms as educators in public school systems continue to look for novel ways to close achievement disparities, foster cooperation, and critical thinking, and incorporate 21st-century literacies. Educators are looking for the optimal tools and strategies to use to raise student achievement considering the expanding trend of wireless technologies and the growing focus by school districts on one-to-one technology programs. Teachers must critically consider the best approaches to using new technology as they develop.

U.S. and World Educational Ranking

Math is a challenge for high school students in the United States. The U.S. was placed 9th in reading and thirty-first in math literacy out of 79 nations and economies in the most recent results of Programme for International Student Assessment, an international exam administered to teens (OECD, 2023). The proportion of top math pupils in America is lower than the global norm, and math test scores have largely remained unchanged for 20 years. Experts claimed that rather than training students to think creatively about solving complicated problems requiring several types of mathematics, math schools in the United States frequently place a greater emphasis on formulas and procedures (Cresswell & Speelman, 2020). Because of this, it becomes more difficult for students to compete internationally, whether on an international exam or in universities and professions that emphasize complex reasoning and data science. According to the 2022 National Assessment of Educational Progress Exam, high school students in most states and practically all demographic groups in the United States have faced alarming losses in math. This is the most conclusive evidence yet of the pandemic's effect on millions of school children. The National Assessment of Educational Progress (NAEP), also known as the nation's report card, assesses a large sample of fourth and eighth grade students. The scores in math were particularly dismal, marking the greatest reductions ever noted on the test. Math test scores decreased in almost every state in the first results since the pandemic started. Less than 26% of high school students achieved proficiency, down from 34% in 2019. Only marginally better were lower secondary students, who saw reductions in 41 states. Math proficiency dropped from 41% to 36% (NAEP, 2023).

In dissecting the reason for the United States poor scores, scores were lowest in states with the biggest increases in income disparity over time, indicating that the degree of income inequality increased with time. Researchers demonstrated that a significant portion of the math achievement gap between economically advantaged and disadvantaged students is attributable to curriculum discrepancies. They also confirmed that low-income students are more likely to be exposed to poorer math content in schools (Flores, n.d.). Curriculum and tracking practices in public schools in the United States are a factor in the widening achievement gap between poor and wealthy students (Schmidt, 2012). This study may provide a way for teachers in lower income areas to have a mechanism to combat this issue.

According to Schmidt, “the rich are growing richer, and the poor are going poorer in this society because there are variations in the exposure to content for low- and high-income pupils” (Schmidt, 2012). It is a fallacy that schools are the great equalizer, helping children overcome the disparities caused by poverty. Previous studies have demonstrated that more affluent students benefit from greater parental commitment and better teachers, and that these advantages can be seen as early as preschool. The impact of the content itself, however, has been the subject of far less research. There were significant differences between the 33 Organization for Economic Co-operation and Development nations investigated, but on average, unequal access to challenging content was linked to around one-third of the social class-related gap in student performance, including in the United States. Unfair access to math curriculum contributed to approximately 58 percent of the disparity in the Netherlands, compared to less than 10 percent in countries like Iceland and Sweden. Nevertheless, the study discovered that both instances of unequal learning opportunities for lower-income students—whether they were discovered within or between schools—exacerbated inequitable student outcomes. A flipped-gamified environment may allow for teachers to close the disparity in mathematics curriculum.

Georgia State Data

In mathematics, the news for America and, to a lesser extent, Georgia is horrendous. Georgia's 2022 scores indicate that a gap still exists. the number of children deemed proficient or better in mathematics by NAEP was 11 percentage points lower than what was recorded by Georgia Milestones Mathematics Exams, which are exams taken by students at the conclusion of particular classes (Tagami, 2022). NAEP examined performance in 26 large urban school districts with high numbers of Black, Hispanic, or low-income children. Atlanta Public Schools performed worse than both Georgia and the other urban school districts. Atlanta's scores declined in mathematics by eight points compared to previous years.

Table 1

NAEP Comparison Scores

National average	Georgia average	Large city average	Georgia urban city (Atlanta, Gwinnett, Dekalb)
235	235	227	224
273	271	266	263

Note. The data is derived from the NAEP 2022 National Math Assessment Scores (https://nces.ed.gov/nationsreportcard/state/).

Georgia has identified a state assessment in which high school students' proficiencies in particular subjects are assessed. Georgia schools administer the Milestone exam in these courses. The Georgia Milestones Assessment System is a comprehensive summative assessment program that encompasses all three levels of the state's education system: elementary, middle, and high school. The system is designed to transmit consistent signals regarding a student's readiness for the next level, whether it be the next grade, course, or undertaking, such as attending college or beginning a profession after completing K-12 schooling. These tests account for 20% of the student's grade in the course.

Table 2

Georgia Milestone Proficiency Scores

School System	Geometry proficient or higher	Algebra 1 proficient or higher
City of Atlanta	12%	34%
Dekalb County	6%	7%
Gwinnett County	7%	6%
Average	16%	20%
State	45%	40%

Note. The data is derived from Georgia Department of Education School Report Card (https://gosa.georgia.gov/dashboards-data-report-card/report-card).

One finds that in these large Urban locations, there are a high number of low-income, first-generation students. According to an examination of income data from the most recent American Community Survey (ACS, 2020), a total of 15,84 households, or 47% of the target area, live at or below the poverty line, compared to Georgia's rate of 14% and the national average of 12%. Additionally, 83% of children attending target schools are eligible for free or reduced lunch, according to the Georgia Department of Education (Georgia Department of Education, 2021). Adults in this urban area lack a high school diploma at a rate of 23%, which is higher than the state average of 19% and the national average of 9%. Additionally, 74% of individuals in the target area lack a bachelor's degree, compared to 68% in Georgia and 63% in the United States. On the other hand, with only 26% of people in the target region owning a bachelor's degree or higher, compared to 32% in Georgia and 37% in the United States, the large urban areas are home to approximately 23,000 adults who do not possess a bachelor's degree and are therefore potential first-generation students (ACS, 2020).

Issues Around First Generation and Low-Income Students in Education

An increasing collection of research illustrates the additional challenges many college students encounter if one or both of their parents did not complete higher education. But a new research brief underlines the difficulties that high school-aged children of non-college-going parents' encounter. The National Center for Education Statistics released a report indicating that "first-generation" college students are less likely to enroll in tough high school courses than their peers whose parents have obtained bachelor's degrees (Bennett et. al, 2018). This report is based on the experiences of over 45,000 students participating in three ongoing longitudinal studies. Only 22 percent of first-generation children who completed high school in 2011-2012 took trigonometry/statistics/precalculus as their highest-level math class, compared to 46 percent of their classmates with college-educated parents. 8 percent of high school students studied calculus as their highest-level math course, compared to 28 percent of college-bound pupils. First-generation students were also less likely to select an "academically focused curriculum," which the NCES defines as four years of English, two credits of the same foreign language, three years of math including a course above Algebra 2, three years of science including a course above general biology, and three years of social studies including U.S. or world history. Students without college-going parents were also less likely to graduate high school within a specified time frame. The study reveals that 92 percent of first-generation students who were sophomores in 2012 had earned a high school diploma or equivalency certificate 10 years later, compared to 97 percent of their peers whose parents had some college experience and 98 percent of those whose parents had earned a bachelor's degree. One reason for this avoidance of math may be math anxiety.

There is a strong correlation between math anxiety and performance, with higher math anxiety associated with lower arithmetic exam scores. While it is unclear which comes first—anxiety or poor performance—it is probably a circle: fear of arithmetic causes avoidance of math practice, which has a negative impact on grades, which in turn affects anxiety. Despite little to no differences in math skills between boys and girls, math anxiety is regularly reported to be more common in females. This might be because girls are more anxious since they are aware of the stereotype that boys are better at arithmetic. Parents or teachers who believe boys will have an easier time with mathematics may propagate this misconception. Math anxiety may have detrimental side effects even in people who perform well in math. When math is genuinely a strength for a child, they may choose not to study it, which prevents them from improving their math abilities as much as they can. Secondary school requires students to focus on fewer courses. They might choose their subjects less based on talent and more on false worry that might be reduced. Students may be preventing themselves from pursuing a future vocation that needs knowledge of or training in mathematics. Even if math anxiety is a problem in and of itself, the connection between math anxiety and academic math achievement is especially worrisome. Higher math anxiety is associated with worse arithmetic performance. Richland (2020) referred to this as a “self-perpetuating cycle.” Anxiety likely worsens performance, while poor performance worsens anxiety. However, little is known about the process of changing the learning environment of these students and how it will affect their motivation and achievement in Mathematics. This study may show that the flipped-gamified classroom may ease the anxiety students have for math and decrease avoidance of the subject.

Student Motivation

Motivating students is one of the most significant issues teachers confront every day. Motivation and engagement, conceptualized as students' energy and drive to participate, learn, work efficiently, and realize their potential at school, play a significant impact in students' interest in and enjoyment of school (Martin, 2006). Clearly, both also play significant roles in academic success (Martin, 2001; Martin & Marsh, 2003). Consequently, motivated and engaged children tend to perform significantly better academically and exhibit better conduct than their peers who are unmotivated and disengaged (Fredricks et al., 2004). Teachers play a crucial impact in the motivation and engagement of their pupils, even though much of the drive is intrinsic to the student. Significant amounts of student involvement and accomplishment can be attributed to teacher and classroom-level characteristics (Hill & Rowe, 1996). Hill and Rowe (1996) explain the significance of motivation and engagement on student learning and conduct, the role of teachers in motivating and engaging students, and strategies for doing so.

Student Engagement

Student Engagement, defined as the propensity to be behaviorally, emotionally, and cognitively immersed in academic activity, is a major notion in motivation research (Thijs & Verkuyten, 2009). Therefore, compared to their less involved colleagues, engaged students exert more effort, experience more good emotions, and pay greater classroom attention (Fredricks et al., 2004). Additionally, participation has been linked to improved student outcomes, such as higher grades and fewer dropouts (Connell et al., 1994). Teachers and the learning environment created plays a crucial impact in the engagement and motivation of their students (Hill & Rowe, 1996). Even though most of a student's motivation and engagement is innate, research demonstrates that teachers play a crucial role in fostering this motivation and engagement.

Martin (2006) demonstrated that a teacher's happiness and confidence in teaching, pedagogical efficacy, and affective orientations in the classroom positively influence student engagement and motivation. According to Bandura (1997), self-efficacy and confidence are similar. Teachers who exhibit confidence or self-efficacy have demonstrated the following: a) the ability to generate and test alternative courses of action when initial success is not achieved; b) enhanced functioning through elevated levels of effort and persistence; and c) enhanced ability to deal with a problem situation by influencing and emotional processes related to the situation (Martin, 2006). According to Bandura (1997), teachers with poor confidence tend to focus on their shortcomings and perceive situations as more challenging than they are. Self-efficacy-high teachers are more likely to engage in pedagogy that is characterized by positive, proactive, and solution-focused orientations, resulting in enhanced student motivation and engagement. It has been demonstrated that teachers' happiness and confidence in teaching significantly influence their affective orientation towards their students (e.g., positive student-teacher interactions), resulting in more student motivation and engagement.

Teven and McCroskey (1997) discovered that when students perceive their teacher to be caring, they believe they can learn more. Moreover, positive teacher-student connections predict increased social, cognitive, and language development in younger children (Kontos & Wilcox-Herzog, 1997). According to Flink et al. (1990), teachers that encourage student autonomy to foster more drive, curiosity, and the desire to be challenged. Positive teacher-student connections relate to emotional, cognitive, and behavioral involvement in class (Connell & Wellborn, 1991). These articles would suggest that when introducing a new learning environment to students, teachers need to be well-trained and feel comfortable and confident in the environment.

Professional development and training surrounding the nuances and development of this new learning environment are essential to the success of the delivery process from the teacher.

The Flipped Classroom

The flipped classroom utilizes educational technology resources and active learning in a student-centered setting to positively influence learning by removing instruction from the classroom (O'Neil et al., 2012). In a flipped classroom, students obtain in-class instruction traditionally from home via Information and Communication Technology (ICT) tools, and class time is spent on concept application (Tucker, 2012). The flipped classroom utilizes educational technology and active learning to move instruction outside the classroom. Unlike typical lecture classroom models, it allows for the independent creation of work (O'Neil et al., 2012). Teachers can now make learning more engaging and accessible for their pupils due to the wide variety of educational ICT resources available. Extensive study has been conducted on the value of technology as a learning tool, but the results are frequently equivocal because it is difficult to quantify the outcomes. Nevertheless, research has identified technology as a component that improves problem-solving, conceptualization, and critical thinking (Culp et al., 1999; Sandholtz et al., 1997).

The flipped classroom can inspire students (Usher & Kober, 2012). In addition, the flipped classroom's adaptability permits the lessons' pace to be matched to the student's learning, as they can view the course at their comfort level and review, pause, and fast forward as needed. The flipped classroom's emphasis on ICTs is enticing to learners, as evidenced by the capacity of technology to motivate children to study mathematics and science (Nugent et al., 2006). Indeed, the flipped classroom is a student-centered approach with the potential to impact student motivation and academic achievement in the following ways. For example, Increase student motivation by focusing less on content delivery in the classroom: students have more time in class to apply and practice concepts and engage in activities and exploration; (Johnson, 2013).

Permit students to participate in learning actively and connect with content instead of passively listening to a lecture (Knewton, 2012). This can enhance individual motivation.

Enhance academic achievement (Kirch, 2012; Fulton, 2012; Green, 2012).

Accommodate students' technological aptitudes (Franciszkowicz, 2008).

It is important to discuss the role of inquiry and discourse within the learning process. Inquiry and discourse between peers and teachers are important ways for learning and meaning to be constructed (Mercer, 2010, Oliveira, 2010, Webb, 2009). Students' learning processes and outcomes, as well as their active involvement, motivation, and interest in learning, are all significantly impacted by inquiry, discourse, and interaction quality (Lipowsky et al., 2007; Sierens et al., 2009). Numerous research works on science inquiry and mathematical argumentation highlight the value of key activities in fostering fruitful classroom discussions (Furtak et al., 2012, Kovolainen & Kumpulainen, 2005). Teachers can effectively foster a healthy learning environment, full of inquiry and discourse, by using effective questioning strategies and providing insightful feedback (Jurik et al., 2014). Questioning strategies used by teachers that are meaningful allow pupils to investigate and share their own understanding. Open-ended inquiries are one type of asking strategy that has been demonstrated to generally increase student motivation and engagement through verbal discourse (Jurik et al., 2014). The flipped classroom environment is ideal for this type of inquiry. Students are free to demonstrate their knowledge of the previously viewed lesson through inquisitive reasoning with the instructor, either before class or during class. This also gives the teacher ample opportunity to provide quality feedback to the student. Feedback from teachers is considered to be helpful for learning and motivation when it tells students not only whether a response is correct, but also specifying what details of the response are correct or incorrect, how to fix any errors, or when it generally supports the learning process (Hattie & Timperley, 2007). It is very possible that the flipped classroom provides an environment which inquiry and discourse can be enhanced over the lecture-style teaching environment.

In conclusion, the flipped classroom is one student-centered strategy that accomplishes allowing access to education in various ways in a student-centered manner by permitting students to actively develop their knowledge while engaging with learning resources in an ICT environment. It has been demonstrated that these types of hands-on learning activities enhance children's science learning, achievement, and attitudes toward science, as well as their science skill mastery, language development, and creativity (Haury & Rillero, 1994). However, it has been suggested that more may be needed to motivate students within the flipped classroom environment. Gamification is a technique which may be the missing factor with assisting with providing further motivation to students within a flipped classroom environment.

Gamification

Gamification is a complicated concept, and there has been considerable confusion regarding its definition. It is most frequently defined as the application of game design elements to non-game contexts. Gamification uses game-based elements and strategies to increase engagement, motivation, learning, and even solve problems. Frequently, analogous definitions are used to provide additional clarification or to tailor a term to a particular field. Gamification in education is defined as the use of games, game-like activities, or game elements (such as badges, leaderboards, tokens, or similar mechanisms) to enhance learning, motivate students in the learning process, and/or increase student engagement in an academic course. The greatest attraction of applying gamification to an activity or a course is that it encourages increased involvement and engagement. Increased participation can frequently ensure the retention of participants and aid in the formation of communities that facilitate enhanced collaboration (Aguilos & Fuchs, 2022).

Eckleberry-Hunt and Tucciarone (2011) determined the successful strategies for gamification implementation will include hands-on instruction, simulations, and group discussion. Gamification offers teachers an innovative method for enhancing their content and instruction. Moreover, learners, especially millennials, desire team-based interaction and immediate feedback; gamification can provide the necessary context to meet these needs. Gamification can provide users and students with a sense of accomplishment and advancement if properly implemented. Certain aspects of gamification capitalize on human competitiveness and the desire to excel. Typically, gamification outlines clear objectives but does not always explain the process. A goal should give learners the freedom and autonomy to pursue it using a variety of techniques and approaches. By allowing the user to fail, they can experiment and explore various methods of displaying progress. In most cases, gamification will show the individual's progress, which can motivate them to finish that task or course. In these ways, gamification provides a thoughtful way of displaying what individuals have accomplished, allows them the freedom to fail, and encourages them to strive for their personal best.

Problem Statement

Math scores among students in the US have been on the decline over the last several years. Research has shown that particularly first-generation low-income students suffer significant math deficiencies. In addition, their unique challenges add to their already difficult tasks of understanding and comprehending mathematical concepts. However, little is known about the process of changing the learning environment of these students and how it will affect their motivation and achievement in mathematics. This study aimed to focus on how a gamified flipped classroom learning environment would affect motivation and achievement in high school mathematics. The research questions which will be evaluated in the study are:

RQ1: How do students' achievement differ between traditional, flipped, and gamified flipped instructional models as measured by post-test scores?

RQ2: How does student motivation differ between traditional, flipped, and gamified flipped instructional models as measured by scores from the Math Motivation Questionnaire?

RQ3: How does student engagement differ between traditional, flipped, and gamified flipped instructional models as measured by the Student Engagement in Mathematics Scale?

This study was conducted with the pre-collegiate summer program students at a University within the State of Georgia. These students are first generation-low-income students within the Atlanta Public, Dekalb County, and Gwinnett County Public School systems. The study took place over six-weeks during a summer program with 69 students participating in the study.

CHAPTER 2. LITERATURE REVIEW

The focus of the research was to determine the impact a gamified flipped learning environment will have on motivation and achievement in a summer enrichment high school mathematics course for high school students. The intervention was designed to create a learning environment that fosters motivation, engagement, and high-level achievement. This literature review will demonstrate how a gamified flipped classroom learning environment, using a Self Determination foundational model, can motivate students and increase achievement in a high school Mathematics Class. Self Determination Theory focuses on the increase of student motivation by addressing the need for the learner's autonomy, relatedness, and competence. By addressing these needs, the study examined how a learning environment can be created to foster students' motivation within the subject area. The flipped learning environment, which is an inverted version of a traditional learning environment, can be an ideal environment where each of these needs can be addressed. The enhancement of the flipped classroom learning environment, using gamification, can provide further encourage the learner’s autonomy and competence. The research examined for this study will connect the current understanding of the interactions between these topics and bolster the proposed study being accomplished.

Self-Determination Theory

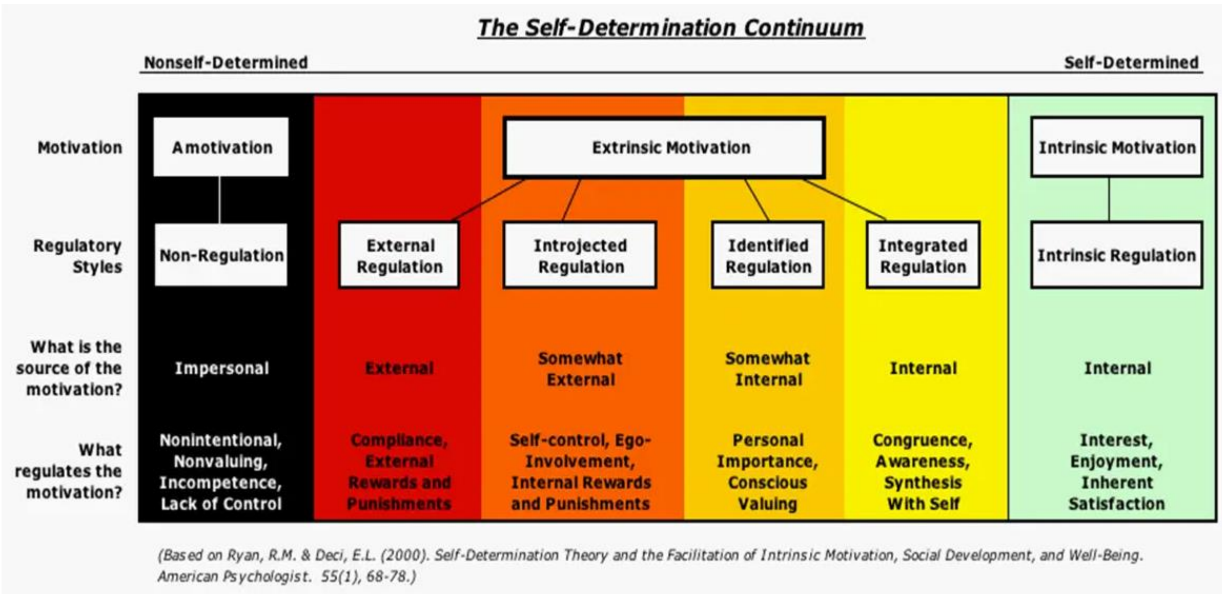
Individual behavior is governed by two types of motivation, intrinsic and extrinsic, according to Self-Determination Theory (Deci et al., 1991). Intrinsic motivation is an individual's innate inclination to explore, investigate, and learn about novelty and difficulties. Extrinsic motivation refers to performance that is influenced by an external factor. When people find a task engaging, they do it gladly (Ryan & Deci, 2000). The research has examined feelings of autonomy (self-regulated behavior) and motivation in schools. (Ryan & Deci, 2000; Ryan & Grolnick, 1986).

Particularly in educational contexts, students' autonomy has been connected to intrinsic motivation (Deci et al., 1981; Ryan & Grolnick, 1986). Positive outcomes including decreased anxiety, increased academic success, and everyday enjoyment are related to intrinsic motivation. Self-determination theory (SDT) holds that when an individual is self-determined, they are motivated by their inherent nature (Reeve et al., 2004,). Being self-determined means having control over one's own accomplishments and having an internal motivation to act. Self-determination stems from a sense of personal autonomy, in which people believe they are the creators of their own acts and have the freedom to choose for themselves (Deci & Ryan, 1985). According to SDT, when people's needs for competence, relatedness, autonomy, and individual control are met, they become more motivated.

Competence is defined as the ability to see chances to influence others in a variety of settings, feel successful, and act with confidence and effectiveness (Deci & Ryan, 2002). The need for social connection is driven by the need to provide care and be cared for by others. Examining how teacher expectations may affect students' conduct and how classrooms may either support or block fundamental needs is consistent with the context-dependent premise of Self-Determination Theory in educational settings. Based on its various forms along a spectrum—amotivation (lack of drive to act), intrinsic motivation (acting for personal satisfaction or enjoyment), and extrinsic motivation (acting for external approval or outcomes)—self-determination theory (SDT) suggests that motivation can be analyzed in various contexts. Both intrinsic and extrinsic motivation have variations, with self-determination being most clearly demonstrated in intrinsically motivated action (Grolnick et al., 2002). Figure 1 depicts the self-determination continuum, and Ryan and Deci (2000) provide a thorough examination of the many types of motivation.

Figure 1

Self Determination Continuum



Amotivation represents a lack of purpose to act, while intrinsic motivation involves acting for its own sake, for enjoyment, and not due to external pressure. There are four types of motivation between these two extremes: external regulation, introjected regulation, identified regulation, and integrated regulation.

Motivation and Achievement

Motivation has as many as 102 definitions (Kleinginna & Kleinginna, 1981), but it is generally recognized as a situation that either fuels or defuses behavior. According to numerous theories, motivation is the result of people's thoughts, expectations, and goals toward a desired behavior. Confidence in oneself can result in behaviors that support and regulate academic accomplishment, like putting in effort, showing tenacity, and setting appropriate goals.

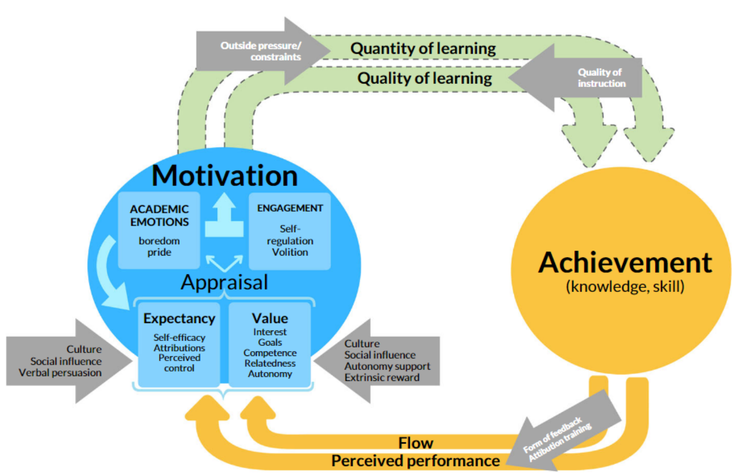
Covington (2000) suggests that students who hold strong self-beliefs tend to attribute high importance to academic activities, which can impact their academic progress. Academic activities are considered important, inherently interesting, with high expected benefits, and minimal effort, leading to high levels of success (Valentine et al., 2004). According to the self-determination theory, feelings of competence lead to intrinsic motivation, causing academic pursuits to be valued more highly when an individual feels competent. This would then result in subsequent achievement-supporting behaviors. A study with over 30,000 college students found that the desire for competence is the most reliable predictor of reported learning gains compared to the need for autonomy and relatedness (Yu & Levesque-Bristol, 2020). The independent study factor within the flipped classroom (watching of the videos) presents the opportunity for students to satisfy the need for competence, relative to autonomy. Students are allowed the opportunity to gain subject level understanding or develop inquisitions for the instructor for that understanding. Students will develop the belief that in the absence of a traditional lecture, they can understand the mathematics' lesson being taught, developing confidence leading to motivation. Students that possess the ability to oversee their own learning processes are able to sustain their interest in the learning cycle. If a student values an academic outcome and believes he or she has some control over it, he or she may be motivated to continue in the subject area.

Motivation to Achievement—The How

Although it is widely acknowledged that motivation affects performance, it is not entirely clear how. Two ways are prevalent in the research. The first factor is the amount (frequency and intensity) of achievement-oriented academic activities, such as effort and persistence. (Cury et al., 2008; Dettmers et al., 2009; Doumen et al., 2014; Marsh et al., 2016; Pinxten et al., 2014; Plant et al., 2005; Trautwein et al., 2009). Increased motivation may lead to enhanced academic achievement by utilizing efficient learning techniques, such as a gamified flipped classroom. Various academic motivation theories suggest that increased motivation leads to better quality behaviors. Intrinsic motivation and interest have been associated with deeper learning according to self-determination theory by Deci & Ryan (2000) and studies by Alexander et al. (1994), Schiefele (1999), and Scott Rigby et al. (1992). Positive academic motives can help promote mastery-oriented methods (growth mindset) and innovative learning tactics, as shown by Pekrun (2006) and Burnette et al. (2013). What matters most is the learner's evaluation, and perceived performance. Thus, high perceived performance will alter the learners' expectations (i.e., they will believe that good outcomes are attainable) (Vu et al., 2022), however, it can also change how learning activities are valued. (Bandura,1997; Eccles & Wigfield, 2002; Weiner, 2010). In self-determination theory, the feeling of competence (which is bolstered by positive perceived achievement) is a fundamental need that increases the intrinsic value of learning. Figure 2 provides the cycle how achievement and motivation feed each other.

Figure 2

Motivation and Achievement Cycle



Note. This figure is adapted from Cleary and Zimmerman (2012), Eccles and Wigfield (2002), Schunk and DiBenedetto (2020).

Schunk and DiBenedetto (2020) suggest an iterative connection exists between perceived progress, self-efficacy, and goal pursuit. Extrinsic rewards and requirements linked to performance can modify motivation. The study utilizes gamification to change the perceived worth of academic conduct. Self-determination theory suggests that this could reduce intrinsic drive, but it could also initiate a motivation-achievement loop that would not start otherwise. External factors can also increase the value of learning by fostering autonomy and relatedness, thereby increasing motivation and achievement (Deci & Ryan,2000). Understanding the literature regarding motivation and achievement, the definition for motivation in this study will be the level of effort and focus shown by students in their pursuit of desired academic outcomes.

Social learning and verbal persuasion from others, including classroom interactions with instructors and peers in flipped environments, can change learners' expectations, values, and attributional processes, hence maintaining motivation (Vu et al., 2022). External requirements can lead to success even without intrinsic drive. Learning quality is influenced by motivation, as well as the learner's talents and the quality of training, teaching, and materials. Improved learning assistance can lead to higher achievement, even without a boost in motivation. This can be accomplished through the in-class assistance offered by the lecturer in the flipped classroom approach. Perceived achievement is influenced by both actual achievement and educational design elements, such as the type of feedback provided, which can emphasize a student's ranking or mastery of the study material or focus on effort rather than performance (De Kraker-Pauw et al., 2017). These external elements are crucial for a thorough comprehension of the relationship between motivation and accomplishment, and they also offer opportunities for interventions to enhance motivation, achievement, or both.

Flipped Classroom

Presently, there is a pedagogical trend known as the flipped or inverted classroom, which entails relocating classroom-based activities (e.g., material presentation) to the students' homes and assigning classroom-based tasks as opposed to homework (Bergmann & Sams, 2012; Sohrabi & Iraj, 2016). A reversed classroom model entails the instructor providing assistance to the students instead of simply delivering information; the students are then held accountable for their individual learning progress and timetables (Lai & Hwang, 2016). The instructor is afforded additional opportunities to foster student learning, including hands-on activities, problem-solving based on student suggestions, and discussion, as opposed to dedicating classroom time to lectures. Flipped classrooms, as opposed to traditional instructor-centered education, which views students as passive recipients of knowledge (Betihavas et al., 2016), place the emphasis on the students rather than the instructor (Bergmann & Sams, 2012). Student-centered learning, according to Bishop and Verleger (2013), encompasses a variety of approaches, including collaborative learning, peer-assisted learning, and active learning. Active learning, as defined by Prince (2004), is an instructional methodology that involves pupils in the process of acquiring knowledge. Active learning necessitates that pupils undertake meaningful learning activities and assume accountability for their individual educational progress (Sohrabi & Iraj, 2016; Blaschke, 2012). Flipped classrooms afford students the opportunity to engage in higher-order thinking activities and promote active learning (Lai & Hwang, 2016). Students are transformed from passive recipients to active participants in flipped classrooms, according to Davies et al. (2013). Flipped classrooms provide numerous opportunities for peer-assisted learning, according to Nederveld and Berge (2015). These opportunities include collaborative project completion and in-class cooperative problem-solving, as well as technology-supported extracurricular activities like social networking sites and discussion boards. Collaborative learning facilitates the development of social skills and improves children's comprehension. Active learning is encouraged through participation in small-group activities and student responsibility; the instructor's role is that of a facilitator. In flipped classrooms, rather than imparting knowledge through lectures, instructors engage students in collaborative small-group activities during class time (Bergmann & Sams, 2012; Tucker, 2012). Tucker (2012) emphasized that students can utilize class time for collaborative learning and group projects in flipped classrooms.

It has been established that reversed classrooms improve student learning outcomes, including motivation, engagement, and satisfaction. According to these findings, the efficacy of pre-recorded videos is a critical determinant in improving student learning outcomes. Hal-Zahrani (2015) highlighted the significance of reformatted course materials and tools, specifically video-recorded lectures, in terms of quality. The author emphasized that in order to enhance student engagement and satisfaction, these resources must be meticulously crafted. In order to enhance student engagement, Ryan and Reid (2016) assert in separate studies that video durations should align with the concentration span of the audience. Sahin et al. (2015) found that students found it more convenient to view videos rather than read the course textbook.

The reversed classroom offers the greatest educational benefit of adaptability (He et al., 2016). Students may study at their convenience, regardless of time or location, due to the fact that numerous flipped classrooms utilize online resources to deliver instruction before class begins (McDonald & Smith, 2013). The flexibility of this model allows students to engage in self-paced study, which is especially advantageous for students with hectic schedules who may be absent from class (Bergmann & Sams, 2012). In a similar vein, González-Gómez et al. (2016)

demonstrated that students have the ability to pause, replay, and review lectures by utilizing the technologies that are commonly available in the flipped classroom model. The broad acceptance and satisfaction of both students (Nguyen et al., 2016; Wanner & Palmer, 2015) and instructors (Hardin & Koppenhaver, 2016) regarding the reversed approach can be primarily attributed to its flexibility. The reversed classroom model offers additional pedagogical advantages, such as fostering personalized learning and augmenting students' recognition of lecture content. Additionally, children were found to be better equipped for class as a result of employing this method.

Students developed more favorable perceptions of their educational experiences, according to additional research (Fautch, 2015; Hung, 2015). Additional benefits of rotated classrooms include increased student-instructor and student-student interaction. A plausible explanation for the heightened level of student-instructor engagement could be attributed to the transformation of the instructor's role from that of a mere content presenter to that of a learning facilitator (Bergmann & Sams, 2012). As a result, Gilboy et al. (2015) hypothesized that student-centered activities in the reversed model classroom could potentially increase instructor-student engagement. One additional purported advantage of the reversed classroom model is the ability to optimize the utilization of class time. Class time may be devoted to student-centered learning activities such as interaction, feedback, practical application, and so forth, given that all lectures are designated as assignments to be completed outside of class. As a result, academic time may be utilized more efficiently than in traditional classrooms.

Flipped Classroom and Self-Determination Theory

In relation to the attributes of students' self-determination, the existing body of literature consistently yielded similar findings. According to an analysis (Pelliccione et al., 2017), the implementation of the Flipped Classroom Method (FCM) created an environment in which students were more effectively capable of satisfying their needs for proficiency, independence in their educational pursuits, and connection. FCM provided significant added value, as evidenced by the statistically significant variations observed across all dimensions of self-determination. In particular, Pelliccione et al. (2018) suggest that the FCM fulfilled the students' need for competence, which was to feel capable of effectively participating in the learning process. Previous research (Bhagat et al., 2016) that demonstrated the impact of FCM on students' learning outcomes could be supported by these findings. These observations may offer a plausible rationale for the present findings, specifically that the FCM can be utilized to foster a nurturing environment that enhances students' faith in their capacity to participate actively in the learning process. One could argue that this effect is attributable to the FCM principles, which involve the instructor utilizing classroom time more effectively for (collaborative) activities designed to develop students' competency and for providing feedback and scaffolding throughout this process.

In response to students' inclination towards autonomy, the FCM effectively catered to their requirement to engage in pertinent activities independently and within their personal environment. One could argue that the learning environments established by the FCM enabled this degree of autonomy because it allowed students to devote more time to collaborative peer and instructor projects and practical exercises, as opposed to attending teacher-led lectures that would have limited autonomy. Finally, the findings concerning the necessity for relatedness among students suggest that the ability of the FCM to allocate classroom time for active participation in collaborative endeavors led by both their instructors and peers has a substantial influence on their intrinsic perception of affiliation with a social environment that fosters and advances their education.

The Drawbacks of the Flipped Classroom

Even though flipped classrooms provide several benefits in educational settings, this paradigm also offers significant obstacles. The bulk of issues associated with flipped classrooms are associated with out-of-class activities, such as insufficient student preparation before to class and the need for coaching at home. The most often cited issue is pupils' inadequate preparation before class. If a student does not devote time to studying at home, they may not do well in the classroom activities, hence reducing the benefits of the flipped classroom (Sayeski et al., 2015). As stated by Hwang et al. (2015), engaging students in self-directed learning at home is one of the fundamental components of seamless flipped learning. Since students may not be acclimated to this paradigm, they may get disoriented (i.e., not know what to do) in the flipped model. To prevent this predicament, they want clear guidelines on how to use their pre-class time and course materials. Another pedagogical concern is the inability of pupils to get timely assistance or feedback when studying at home. Typically, students who require assistance during extracurricular activities must take notes, jot down queries, and wait for class discussions to acquire answers. Some researchers provided their students with rapid feedback during out-of-class activities by using text messages or discussion forums (Cummins et al., 2016; Fautch, 2015; Hardin & Koppenhaver, 2016). Additionally, these technologies aid in reducing transactional distance in the flipped model (Chen et al., 2014). In addition, there were also worries over the difficulties of ensuring that students thoroughly review each lecture before class. The flipped format demands more time and effort from the students' viewpoint than a normally scheduled course. This may be due to the nature of this program, which encourages students to examine course materials before class for enhanced involvement (Hung, 2015). In this regard, Smith (2013) found that students saw studying lectures outside of the classroom as an additional time burden. According to (Chen et al., 2014), some of the students may have developed passive learning habits in the conventional classroom, where learning needs less time and effort. In addition to these challenges, students did not always favor this new paradigm and did not always regard it as beneficial compared to conventional training.

In addition to the downsides of the FCM, the research discussed in this section suggests that students must possess strong motivation and independent learning abilities to thrive in a flipped classroom setting. Seeing how the FCM could enhance the key components of Self-Determination Theory, which focuses on self-motivation, to bolster student motivation, the use of gamification may provide a bridge to the downsides of FCM. Gamification, also theoretically founded in Self Determination Theory (Deci & Ryan 2004), should aim to motivate users internally by providing a sense of autonomy, competence, and/or social commitment (Tsay et al., 2018).

Gamification

Gamification is the act of introducing game features to non-game circumstances (Zimmerling et al., 2019; Schobel et al., 2020; Ding et al., 2018; Domnguez et al., 2013). Levels, points, badges, leaderboards, and avatars are the most often used game features in diverse disciplines of study (Barata et al., 2017). These techniques, referred to as 'components' in gamification, encourage learners to attain better goal orientation through improving their perseverance, learning via repetition, participating in cooperation, and invoking friendly rivalry with colleagues (Ding, 2019). Malone (1980) introduced the concept of gamification, while Sawyer and Rejeski (2002) established the 'Serious Games Initiative' to promote serious game-based approaches in education due to the positive effects of game elements on learners' motivation and engagement (Zhonggen, 2019).

Gamification and Self-Determination Theory

Many studies on gamified learning have chosen self-determination theory (SDT) as their theoretical framework since it aligns with established learning theories. Seaborn and Fels (2015) stated that SDT is the predominant psychological theory utilized in gamification research. The provisions promote a student's sense of autonomy, competence, and relatedness, as these psychological demands are supported by internal motivation (Buil et al., 2020; Nishihara et al., 2020). Addressing the three essential psychological criteria of children enhances their intrinsic motivation. Increased satisfying of these demands leads to higher levels of intrinsic motivation in gamified activities. Buil et al. (2020) provide direct evidence utilizing Self-Determination Theory (SDT) to incorporate several elements of game design that motivate students and fulfill their needs for competence, autonomy, and relatedness. Gamification enhances the educational experience and learning exercises by increasing engagement and encouraging students to participate actively using digital means like earning badges and aiming for the top position on a scoreboard (Barata, 2017; Baydas & Cicek, 2019). Gamification elements like badges, levels, and leaderboards can enhance student motivation and enhance their learning experience, engagement, and performance (Shane, 2022). While the above studies have shown that the incorporation of game features increases student engagement and the research earlier demonstrates that increasing engagement can increase motivation, it would follow that the use of gamification can increase motivation. The issue at hand is regarding which type of motivation is affected by gamification, whether it merely promotes extrinsic incentive in its entirety, or if there is an effect on intrinsic motivation.

Gamification and Motivation

Gamification may be an effective motivator. Various studies have demonstrated that utilizing elements of games as extrinsic incentives as well as rewards effectively targets the extrinsic motivation of learners (Buckley, 2017). This finding aligns with Ding et al.'s (2017) research, which revealed that gamification offered students a significant extrinsic incentive but did not enhance intrinsic motivation. Extrinsic rewards are believed to diminish intrinsic motivation from a pedagogical perspective (Mekler et al., 2017). Several researches have claimed that gamification impacts both extrinsic and intrinsic motivation (Adukaite et al., 2017; Jurgelaitis et al., 2019). The basic elements of games are naturally enjoyable and pleasurable for players, and are commonly linked to internal motivation. The positive impact of attracting, motivating, engaging, and retaining users in gamified learning is known as intrinsic motivation (Kuo & Chuang, 2016). The augmentation of students' learning engagement through the implementation of the gamified learning strategy (Ratinho & Martins, 2023), which seeks to fulfill the three fundamental needs of competence, autonomy, and relatedness, is significantly influenced by both intrinsic and extrinsic motivation. Integrated regulation possesses intrinsic qualities; an individual's behavior is motivated by self-awareness (Deci & Ryan, 2002). This implies that a successful gamification design seeks to understand and establish a correlation between the learning objectives and the learner's intrinsic motivation. Students (the players in this instance) are motivated to commence their pursuit of mastery through a synergy of extrinsic incentives and an intrinsically gratifying framework. For this process to cultivate learning engagement, desire, motivation, challenge, reward, and feedback are required. Student academic achievement is invariably correlated with levels of engagement and motivation. Stronger intrinsic motivation and greater participation are correlated with greater student engagement

(Coffman, 2013). The significance of student engagement in the teaching-learning process is associated with improved student conduct, enhanced higher-order critical thinking skills, and more meaningful learning experiences, according to this research. Scholarly investigations have established the comparative advantages of intrinsic motivation, specifically that motivated pupils are more inclined to exhibit complete engagement in the educational process; furthermore, students will derive greater pleasure and satisfaction from learning, and will be more intrinsically motivated (Bureau et al., 2022). Research has shown that gamification not only increases student engagement and enthusiasm, but also improves academic performance.

Gamification and Achievement

In a gamified system, the notion of 'challenge' significantly contributes to good learning outcomes. Adapting gamified ideas to improve student learning results is described by a variety of ways. As reported in some studies (Huang et al., 2019; Jagut et al., 2018; Jo et al., 2018; Lo & Hew, 2018; Zainuddin, 2018), integrating this concept into contemporary pedagogical instruction such as flipped learning could be an alternative and effective strategy to enhance students' learning achievement. Integration of gamification into the grading process or as a tool for novel assessment was shown to be responsible for the improvements in student learning accomplishment reported by several studies. The most common instrument was a gamified formative assessment system that gave immediate and useful feedback. In accordance with this, many publications, especially experimental research studies, have found that gamified assessment increased students' feedback and scores in comparison to traditional assessment without gamification. Moreover, a number of studies have found that motivation is an important predictor of student academic achievement and that it influences the amount of effort and time a student devotes to learning (Akroglu et al., 2017; Chang & Wei, 2016; Davis et al., 2018;

Goksün & Gürsoy, 2019) This research suggests that there is a positive relationship between student involvement and learning accomplishment; the more involved students are, the higher their achievement. Urquijo and Extremera (2017) concluded that the students with higher levels of engagement had higher academic achievement. Casuso-Holgado et al. (2013) discussed that the students with the highest levels of engagement would be more likely to have the best academic achievement. Sbrocco (2009) concluded that student academic engagement can predict student academic achievement and added that the more engaged students are, the higher their academic achievement will be. Gunuc (2014) found that cognitive, behavioral, and emotional engagements predicted academic achievement.

Despite the intrinsic influence of gamification in education sectors, significant difficulties are also discussed. The primary ineffectiveness of gamified learning was due to the usage of game-based components, instructional design, and technological difficulties. This research suggests that the introduction of extrinsic motivators, such as virtual awards or accomplishment points, does not necessarily ensure that students will be more interested or concerned. Kyewski and Krambeck (2018) found that the use of badges did not boost intrinsic motivation throughout the teaching time. According to other research, the usage of points, badges, levels, and leaderboards failed to foster a feeling of community among students and did not significantly boost their competence, desire for fulfillment, or intrinsic drive (Ding et al., 2017; Mekler et al., 2017). It seemed to not be an efficient approach to motivating students. Recent research indicates that the prevalence of reward systems might potentially hinder students' intrinsic drive to participate willingly in gamified learning for its inherent enjoyment and fulfillment (Derfler-Rozin & Pitesa, 2020; Eyupoglu & Nietfeld, 2019; Facey-Shaw et al., 2020). Badges failed to boost intrinsic motivation, and intrinsic motivation declined over the teaching duration. Points, levels, and leaderboards have contributed to students' extrinsic incentives, but have not substantially boosted students' competency, desire for fulfillment, or intrinsic drive, according to Kyewski and Kramer (2018). Points and badges were insufficient and was unsuccessful in cultivating a sense of community among students (Ding et al., 2017). During the gamification process, students concentrated more on collecting badges and achieving a spot on the leaderboard than on understanding the topic in detail (Baydas & Cicek, 2019). Students' performance declined as the degree of difficulty increased and they felt discouraged (Jagušt et al., 2018). Regarding the impact that external incentives might have on students' intrinsic motivation, the responsibility of instructors and educators in selecting game dynamics that emphasize meaningful learning and that fit the unique learning objectives and content of the curriculum will be crucial. Many of the above-mentioned studies in which gamification was found to have no impact also discussed the need for more meaningful connections between the game and the learning objectives. The addition of the gamification was just an external tool with no connection to the subject matter.

The gamification research complements SDT in that learning tasks should be constructed with optimum difficulties and suitable game features should be chosen depending on the study goals (Denisova et al., 2020; Ryan & Rigby, 2020). Given how both the flipped learning environment and gamification have a theoretical foundation in SDT, utilizing gamification to enhance the flipped learning environment would bolster the ability to increase student motivation.

Gamification and Flipped Classroom Method

In flipped learning, gamification is considered a strategy to increase student motivation (Lo & Hew 2017). Students must be encouraged to do out-of-class activities for flipped learning to have a beneficial impact (Huang & Hew, 2018). Students must improve their involvement and motivation within the flipped classroom since most learners lack the enthusiasm and motivation to continue learning (Zichermann & Cunningham, 2011). Incorporating game-based ideas that are already recognizable to students may make a difference (Azmi & Singh, 2015). Incorporating game-like aspects into flipped classroom environment enhances student engagement (Ding et al., 2018), improves the quality of students' interaction, and boosts students' motivation (Huang et al., 2019b; Hakulinen et al., 2015). Prensky (2001) contends that gaming elements may offer the required enjoyment to interest students in the learning process. Also, borrowing and combining gaming components into instruction may boost involvement and engagement (Antonaci et al., 2019).

Summary of the Literature

The literature discussed in this section has provided an excellent foundation for this proposed study. Self Determination Theory is an appropriate theoretical foundation given its current use of increasing motivation. However, given that increasing achievement is also a proponent of the study, the literature demonstrates a direct relationship between the two: when motivation is increased, achievement is also increased. The flipped learning environment is such that lends itself to supporting the autonomy, relatedness, and competency needs of learners. The research discussed its connection and foundation in SDT and success in achieving both increases is motivation and achievement for the learner, which is why it is chosen for this study. However, the research indicates that some students need additional enhancements to flourish in the flipped environment. Gamification, also founded in SDT, has been shown to increase student motivation within the flipped environment, by increasing student engagement. Enhancing the flipped learning environment with gamification should assist in increasing student achievement and motivation within high school mathematics.

CHAPTER 3. METHODOLOGY

The purpose of this chapter is to introduce the research methodology for this quantitative, experimental study regarding the effect the lecture style, flipped, and gamified flipped classroom has on motivation and achievement in a high school mathematics class. This approach allowed for a deeper understanding of how a learning environment can affect students' motivation to increase their achievement in a math class and provides a way to develop a theory from the data to understand the relationship between motivation and achievement.

Research Questions

This research study compared students' motivation and achievement in a gamification-enhanced flipped learning environment with the behavior of their non-gamified flipped and traditional learning counterparts. The following research questions applied to the study:

RQ1: How do students' achievements differ between traditional, flipped, and gamified flipped instructional models as measured by post-test scores?

RQ2: How does student motivation differ between traditional, flipped, and gamified flipped instructional models as measured by scores from the Math Motivation Questionnaire?

RQ3: How does student engagement differ between traditional, flipped, and gamified flipped instructional models as measured by the Student Engagement Scale?

Research Context

Participants

Participants in this study were enrolled in the specialized federally academic enrichment and enhancement program designed to assist students with preparatory skills to enroll in a program of post-secondary education. The project consisted of 231 students, who were enrolled in grades 9th and 10th graders within several local public-school systems. According to the U.S. Department of Education (USED), the program is a federally funded program designed to "generate in program participants the skills and motivation necessary to complete a program of secondary education and to enter and succeed in a program of postsecondary education (USED, 2019)." The Department of Education dictates that participants in the program must meet the following eligibility criteria for admission into the project: US Citizenship, First Generation/Low Income/At Risk Criteria, demonstrating a need for academic support, must be currently enrolled in a target high school and not above the age of 19. While the criteria dictate that all students must meet the citizenship, need, and high school criteria, two-thirds of the participants must be classified as potential first-generation college student and must meet low-income guidelines. The remaining one-third of the participants must be either first-generation potential college student, low-income individual, or an individual at high risk for academic failure. It is important to note the definitions of these criteria to understand the population of the participants. USED defines a potential first-generation college student as (1) An individual neither of whose natural or adoptive parents received a baccalaureate degree; or (2) A student who, prior to the age of 18, regularly resided with and received support from only one natural or adoptive parent and whose supporting parent did not receive a baccalaureate degree. Low-income individual means an individual whose family taxable income did not exceed 150 percent of the poverty level amount in the calendar year preceding the year in which the individual initially participates in the project. An individual who has a high risk for academic failure means an individual who (1) Has not achieved at the proficient level on State assessments in reading or language arts; (2) Has not achieved at the proficient level on State assessments in math; (3) Has not successfully completed pre-algebra or algebra by the beginning of the tenth grade; or (4) Has a grade point average of

2.5 or less (on a 4.0 scale) for the most recent school year for which grade point averages are available. This study utilized 69 participants from the summer program.

Summer Program Details

The program executed an intensive 6-week residential summer academic enrichment program designed to simulate a college-going experience for its participants. The academic part of the summer program is meant to help students get ready for the high school classes they will be taking in the fall. Students take five core classes: math, science, English, a foreign language, and financial literacy. Each core class lasts 55 minutes in duration and is taught by a qualified high school or collegiate-level instructor. In addition, students will also take an elective class, which will last for 2 hours. Classes take place Monday–Thursday from 8:00 a.m. to 4:00 p.m. Each class is given a tutor who helps the teacher during class and is available to help students in the residence hall at night.

Intervention Program

The intervention took place within the Algebra 2 & Geometry class, which is the largest, spanning 3 sections. Each section had 23 students assigned. Each section was taught by the same instructor, but each section had a different instructional method. All classes covered the same syllabus of instruction for six weeks. The time allotment for this class was 55 minutes for 4 days a week spanning 6 weeks, totaling 22 hours of instructional time. Students also had access to tutoring, via study hall and optional tutoring sessions in the evening conducted by an assigned assistant to the class.

Before the start of the summer session, students took part in a specialized note-taking session. Although many students are adept at cramming for exams, they may not internalize the material. Consequently, they can recognize information on an exam or test, but they are unable to recall facts spontaneously, meaning they cannot discern or construct meaningful connections between topics. The purpose of learning is therefore to transfer information from short-term to long-term memory so that the student can personalize the lesson. For students to "own" a lesson and assimilate its concepts into their thought processes, they must learn to repeatedly engage with the material. As it pertains to note-taking principles, active, repeated familiarity is crucial. To accomplish this, students were introduced to the Rule of 7:

1. Seeing: Read the textbook carefully.
2. Hearing: Listen attentively to the teacher.
3. Writing: Take notes in class.
4. Speaking: Explain the concept to a peer.
5. Creating: Draw representational pictures that coincide with class notes.
6. Shading: Highlight or color-code class notes, categorizing the data.
7. Visualizing: Recall what the notes look like, where they appear on the page, what color ink the student used.

To complement this, students were also taught how to utilize the Cornell Note-Taking Method. The Cornell Method is not so much a method for taking notes as it is for organizing and analyzing data. The student creates a useful study guide by partitioning a sheet of paper into three distinct sections. The student begins by drawing a Cue Column on the left. The student then draws a wider Note-Taking Column on the right and allocates space at the foot of the page for the Summary. During a lecture or discussion, the student records key points of conversation in the Note-Taking Column. The student then condenses the information in the Note-Taking Column and writes a summary in the Cue Column shortly thereafter. In the Cue Column, students should also include queries, terms, or observations. By covering either the Note-Taking

Column or the Cue Column, the student can review and assess his or her understanding of the material. Finally, the student should ponder on the entire lecture and synthesize the main points in the Summary.

The Teaching Techniques

Lecture Style. The instructor prepared and conducted a traditional in-class lecture each class period where the instructor used visual aids, including a projector and whiteboard to convey and explain mathematical concepts to students. The instructor began with a review of previous material and demonstrated how the new concepts build upon and connect to the previous material. The instructor also incorporated practice questions and exercise drills to assist in the learning process. The instructor provided feedback during the class period and will assign homework based on the lesson taught within that class period. The homework was submitted on the next class day. This teaching style is equivalent to what students are exposed to within their normal school parameters.

Flipped. The students received the same lectures as the traditional students in the form of pre-recorded lessons via the program's Learning Management System page and YouTube channel. Students were asked to watch and take notes prior to attending class. During class, those students worked on what is considered the traditional homework assignment while the teacher circulated the room to answer questions from individuals and small groups of students. Students had the opportunity to ask question and obtain help from either their peers or the teacher on any part of the assigned video lecture. In addition, students were able to demonstrate understanding of the material through the in-class activities assigned by the teacher.

Gamified Flipped. The students received the same lectures as the flipped students in the form of pre-recorded lessons via the program's Learning Management System page and

YouTube channel. Students were asked to watch and take notes prior to attending class. During class, those students worked on what is considered the traditional homework assignment while the teacher circulated the room to answer questions from individual and small groups of students. The class utilized Classcraft, a point-based learning system to gamify the learning environment. Students created an avatar and were immersed in a fantasy story where they joined a clan and assisted in navigating through fantasyland. Students earned points, power-ups, and other abilities as they completed elements of the course. For example, students earned 100 XP for watching the lesson, up to 15 GP on their ability to adequately take notes, 10 XP per every in-class question answered correctly.

Table 3

Classcraft Point System

+125 XP	+20 GP	Showing self-control	
+100 XP	+15 GP	Successfully Watching Video Lesson	
+100 XP	+15 GP	Being prepared to learn, Submit adequate notes	
+125 XP	+20 GP	Making a plan to achieve a goal	
+100 XP	+15 GP	Seeing something, saying something	
+125 XP	+20 GP	Considering others when making decisions	
+100 XP	+15 GP	Showing personal responsibility in decision making	
+100 XP	+15 GP	Successfully completing in-class assignment	
+125 XP	+20 GP	Being kind to others	
+100 XP	+15 GP	Listening carefully while others speak	
+100 XP	+15 GP	Contributing to the group's success	
+100 XP	+15 GP	Considering others' opinions	
+125 XP	+20 GP	Working to accomplish a group goal	
−3	Hearts	Acting impulsively	
−2	Hearts	Giving up when faced with a problem	
−3	Hearts	Not coming to class prepared (No notes and No supplies for class)	
−3	Hearts	Disrupting the Class	
−4	Hearts	Failure to watch video	
1	Crystal	Level 1	The student is excused from being chosen to answer a question.
1	Crystal	Level 1	The student can wear headphones during class work.
1	Crystal	Level 1	The student may eat in class today.
Guardian			
1	Crystal	Level 2	The student grants themselves or a teammate up to a maximum of 2 shields to prevent Heart loss.
2	Crystals	Level 5	Extra Day on Classroom Assignment
1	Crystal	Level 9	Student gains up to 1 Heart plus 1 Heart per 5 levels
1	Crystal	Level 13	Student gets a hint on a question

2	Crystals	Level 17	The student grants themselves or a teammate up to a maximum of 4 Shields that prevent Heart loss
4	Crystals	Level 23	Everyone on the student's team gets an extra day for an assignment.
3	Crystals	Level 29	The student grants everyone on their team except themselves up to a maximum of 2 Shields that prevent Heart loss.
3	Crystals	Level 35	Everyone on the student's team gets a hint on a question.
Healer			
1	Crystal	Level 2	A team member gains up to 2 Hearts.
1	Crystal	Level 5	The student may take a short break from classwork.
3	Crystals	Level 9	The student prevents one of their teammates (excluding themselves) from falling once: they'll remain at 1 Heart and avoid all penalties for falling.
2	Crystals	Level 13	The student may work with a partner on an individual assignment.
4	Crystals	Level 23	All team members, other than the student, gain 3 Hearts.
3	Crystals	Level 29	A team member gains up to 9 Hearts.
4	Crystals	Level 35	The student may use their notes during an assessment.

While assigned to a group, students had the ability to work independently to complete the course. In-class activities allowed students to gain points and use their power-ups during the class period. Students worked in groups and independently to demonstrate understanding of the assigned lesson. Students had the opportunity to ask questions and obtain help from either their peers or the teacher on any part of the assigned video lecture. The in-class activities were derived from the functions of Classcraft inclusive of random pickers and boss battles.

Instructional Videos and Cognitive Load Management

Video creation for the flipped and gamified flipped environments followed a structured practice designed to reduce cognitive load, increase germane load, and maximize student engagement and active learning. Each video was no longer than 6 minutes in length. Videos were broken into sections for easy navigation. The video started with upbeat music and an introduction of the topic. The music then faded to minimize any further distractions. The background of the teacher was a solid color as to also minimize distractions. The instructional portion began with an outline of the topic, including timestamp markers. As the instructor provides keywords or concepts, those words were highlighted in a green color to signify importance to the learner (enhancing germane load and reducing extraneous load). The instructor expanded on the use of conversational language, instead of formal language in each video. The instructor attempted to create a sense of partnership with the students by using the pronoun “your” rather than “the”. In addition, the instructor used ownership with the word “I” when speaking in their perspective. The instructor communicated with enthusiasm regarding the subject, utilizing specialized transition words including “I like this next part” or “this next section is going to be fun,” The instructor spoke at a rate of 185 to 254 words per minute range. Any material that links to a prior video or prior knowledge was preceded by a gentle audible sound. A link to the preceding video or review of the prior knowledge was included in the video description. Throughout the video, students were prompted with interactive questions that paused the video and assess the student's understanding of the material. The student had the ability to rewind to review but was not able to move forward without the selection of the correct answer. Prior to these questions, the instructor provided an example of the future problem, using guiding questions within the explanation of the example. At the conclusion of each video, the instructor provided positive feedback and reinforcement for completing the video successfully, in addition to reminding the learner to post questions for discussion during the in-class portion.

The Gamified Environment

Classcraft reimagines the learning experiences of students using gaming principles and empowers them to realize their maximum potential. This gamified learning environment can be a significant means of fostering intrinsic motivation by satisfying participants' requirements for exercising control, developing competence, and experiencing relatedness. Classcraft's features are all linked to the development of various dimensions of intrinsic motivation and are highly effective at fostering engagement. Classcraft's approach to motivation is firmly grounded in the Self-Determination Theory. In relation to autonomy, students can build custom avatars based on their preferences of design. The avatar is how the student maneuvers through the game environment and interacts with their team, though any decisions made by the players are done individually. Students can choose one of three-character classes unlocked in the Collaboration phase: Guardians, Mages, and Healers. Each has its own unique gear sets, pets, and powers. Guardians are the toughest character class and use their magical shields to protect their friends from danger. Healers use their ancient artifacts and bonds with mystical sprites to heal themselves and others. The Mages wield the power of the elements and can transfer their crystals to their allies. They’re very powerful but need to be protected by their teammates.

The student’s avatars are awarded various types of points within the game. Heart Points (HP) are the lifeline of the game. These are the health lines of the characters. Once a player loses all their HPs, the character “dies” and can only be resurrected by completing a special task. However, other team members can use their character’s special powers to restore their teammates’ health points by utilizing Action Points (AP). APs allow characters to utilize their special powers throughout the game. These avatars are equipped with various powers that can be used to assist the student in navigating the game, completing tasks, or being allowed to do special tasks within the class. Students are also encouraged to give special shoutouts (Kudos) to their other classmates as a means of support and encouragement for completing tasks and levels within the class.

In relation to competence, the students can earn or increase their experience points (XP) by completing the assignments or tasks within the class. These can include in-class assignments, proper notetaking from the video, doing well on mini-games, etc. In addition to XPs, students can also earn Gold Pieces (GP), which are a special currency used to buy gear for their avatar or to customize the appearance. This also allows students to take pride in their avatar and can be an element of a show-off to their other classmates. Figure 3shows how the features of Classcraft can assist in motivating its players. Figures 4 and 5 provides demonstrated screenshots of the Practice (Review) activity and Boss Battle.

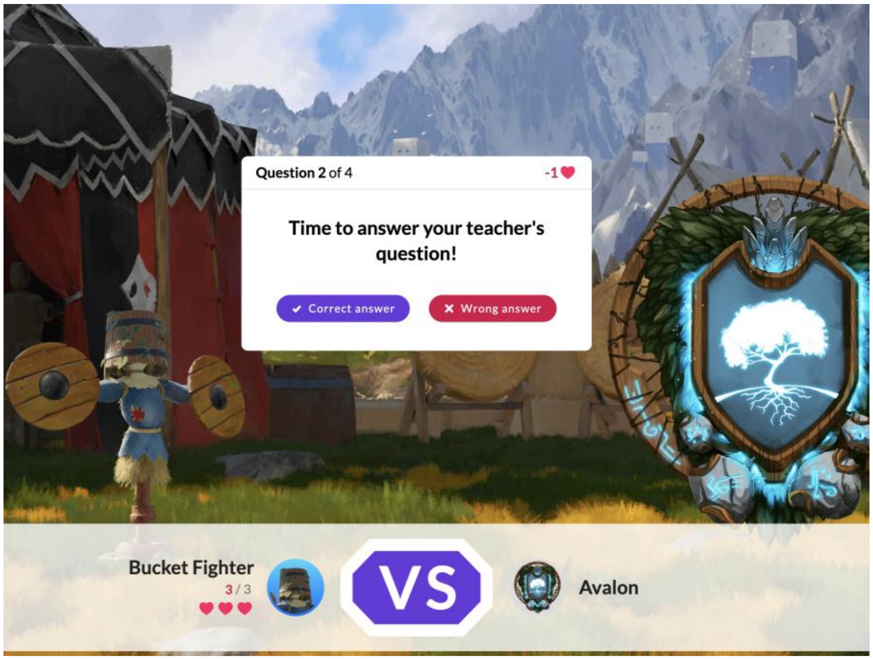
Figure 3

Classcraft Motivation Components

Note. The image is derived from the Classcraft website, https://www.classcraft.com/our-approach/.

Figure 4

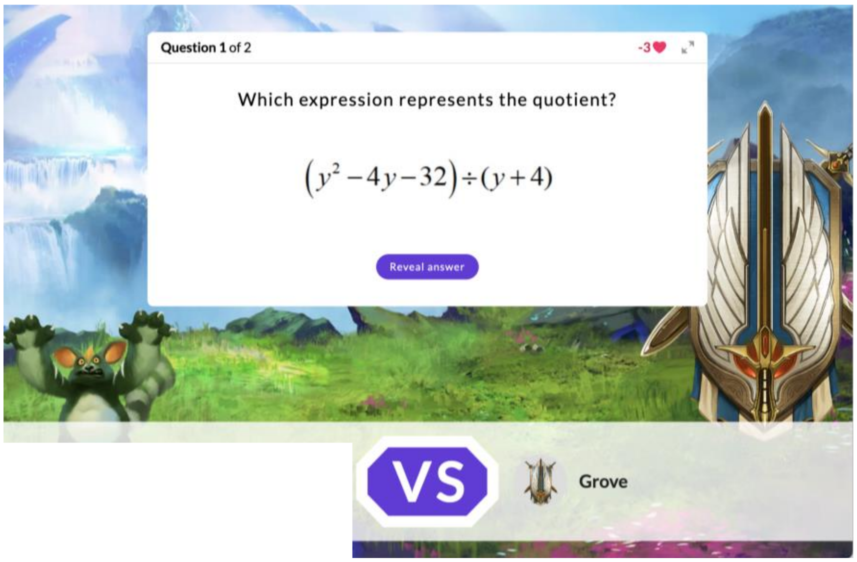
Screenshot of Practice for Assessment



Note. *The image was derived from the Classcraft website, http://www.classcraft.com.*

Figure 5

Screenshot of Boss Battle



Note. *The image was derived from the Classcraft website, http://www.classcraft.com.*

Research Design

The researcher applied a static-group pretest-posttest experimental design quantitative research design to this study. The experimental method studies whether there is a cause-and-effect relationship between the research variables. The researcher manipulates an independent variable to measure its effect on one or more dependent variables. The curriculum for the class was developed based on the Georgia Standards for Algebra This included the following topics: The Real Number System, The Complex Number System, Seeing Structure in Expressions, Arithmetic with Polynomials and Rational Expressions, Creating Equations, Reasoning with Equations and Inequalities, and Interpreting Functions

Data Collection

The researcher collected the quantitative data in the following ways:

Pre and Post-Test Assessments

Each student was administered the identical exam as the pre-cursor to taking the course and as the final exam for the summer course. Though the exam will be constructed by the instructor, the questions for the assessment were derived from the course textbooks used by each of the local school districts where the participants were enrolled. Since the students only had 1 hour to take the exam, a total of 5 questions (divided by the curriculum) was taken from each textbook, which will amount to 15 questions. Each question selected correlated back to the curriculum that was taught during the summer program.

Math Motivation Questionnaire

The Math Motivation Questionnaire is a 30-item instrument intended to assess six factors underlying student motivation in math: intrinsic motivation, extrinsic motivation, self-determination, personal relevance, self-efficacy, and anxiety (Fiorella et al., 2021). Exploratory and confirmatory factor analyses were employed to validate this instrument. For each of the six constructs, the nonlinear SEM reliability coefficients varied between 0.76 and 0.91. Intrinsic value, self-regulation, and self-efficacy exhibited significant positive correlations with mathematics achievement (n = 536), whereas test anxiety demonstrated a significant negative correlation (n = 536), as determined by analysis of a subset of the data comprising students' mathematics standardized scores in order to assess criterion validity. Both prior to and following the course, the survey was distributed electronically. On the following scale, respondents rank the items comprising the questionnaire: Never, Rarely, Sometimes, Usually, or Always. To identify significant disparities among the pupils in each class, the scores will be analyzed utilizing statistical packaging software.

Student Engagement in Mathematic Scale

This Student Engagement in Mathematics assessment is designed to evaluate children's interest in mathematics following a math class (Rimm-Kaufmann, 2010). Students are required to accomplish the task promptly following their math lecture. The scale measures social, cognitive, and affective dimensions of engagement. The sole modification to the student-report measure of social engagement developed and utilized by Patrick et al. (2007) was the addition of the phrase "in math class" to the social engagement dimension of the measure. Additional dimensions were constructed in light of the research conducted by Rowley et al. (2009), Kong et al. (2003), Meece (2009), and Skinner and Belmont (1993). Empirical evidence substantiating face validity, intrinsic rational validity, content validity, and construct validity was gathered to establish the validity of the test (Rimm-Kaufman et al., 2014). Factor analysis supported a high internal consistency-reliability estimate (Cronbach’s alpha value of .92). The instrument contains

13 Likert scale questions and 1 open-ended question. The survey was offered electronically in both pre-course and post-course fashion. Scores were analyzed through statistical packaging software to determine significant differences between the students in each of the classes.

Statistical Analysis

A one-way analysis of variance (ANOVA) was performed to compare the effect of each teaching technique. (Lecture, Flipped, and Gamified Flipped) on achievement, motivation, and engagement. To begin, the researcher ensured all assumptions were met. The researcher ensured the dependent variables of (achievement and motivation) were a continuous scale measured through Pre and post-test scores and survey data. The independent variable for the study were the three independent groups (Lecture, Flipped, and Gamified Flipped). The researcher ensured that the data had independence of observations (i.e., Each group had its own set of independent students.) The researcher ensured that the dependent variable was normally or near-to-normally distributed for each group. The researcher ensured there were no spurious outliers within the data and because the groups were equal in size, that ensured homogeneity of variances. A power analysis was conducted with an effect size of .5. Though this produced a moderate effect size, Cohen's benchmarks for determining effect sizes in research on education appeared to be supported by early meta-Analysis of education studies. Lipsey and Wilson (1993) reviewed over 300 meta-Analysis and determined that the average effect size was precisely 0.50. In 2002, significant federal funding for large-scale randomized field trials was initiated by the Institute of Education Sciences (IES), and the U.S. Department of Education imposed a growing expectation for rigorous assessments of grant-funded initiatives. With the emergence of new standards regarding the pre-registration of research designs, hypotheses, and outcomes, the effect sizes of this iteration of field experiments have significantly diminished. A mean effect size of merely

0.06 was observed in 141 RCTs funded by the Education Endowment Foundation and the IES in the United Kingdom, according to Lortie-Forgues and Inglis (2019).

Thus, the choice of a .05 effect size is acceptable. For achievement, scores from the post-test were analyzed to determine the statistical significance between the scores. For motivation, results from the Mathematics Attitudes and Perception Survey were analyzed to determine if there was a significant difference between the three groups within their responses. For engagement, results from the Student Engagement in Mathematics Survey were analyzed to determine if there was a significant difference between the three groups within their responses. For all significant difference found, the researcher conducted a post hoc test, which allows exploration of the difference between multiple groups. For this study, the researcher utilized Tukey’s test to make every possible pairwise comparison. A confidence level of 95% was utilized for the post hoc test. The results provided two metrics to compare each pairwise difference: Confidence interval for the mean difference (given by the values of lower and upper) and an adjusted p-value for the mean difference.

CHAPTER 4. DATA AND RESULTS

The purpose of this quantitative study was to determine if a statistically significant difference existed in academic achievement and motivation between students receiving flipped gamified math instruction as opposed to non-gamified flipped math instruction and lecture-style instruction in an academic summer program for first-generation, low-income students. This chapter will present the findings that addressed the stated purpose and the following research questions under investigation:

1. How do students’ achievement differ between traditional, flipped, and gamified flipped instructional models as measured by post-test scores?
2. How does student motivation differ between traditional, flipped, and gamified flipped instructional models as measured by scores from the Math Motivation Questionnaire?
3. How does student engagement differ between traditional, flipped, and gamified flipped instructional models as measured by the Student Engagement Scale?

The theoretical framework for this study was Self Determination Theory. The lessons designed for the treatment group incorporated aspects supporting the students’ experience of autonomy, competence, and relatedness to foster the most independent and high-quality forms of motivation and engagement within the class. This chapter will present the quantitative findings from the descriptive and inferential statistics that were conducted.

Quantitative Findings

This study was conducted at an intensive 6-week residential summer academic enrichment program. A total of 69 students participated in this study. Table 4 provides a breakdown of class sizes for each of the groups.

Table 4

Descriptive Statistics of the Treatments and Control Student Participants

	N
Traditional	23
Flipped	23
Gamified Flipped	23
Total	69

On the first day of the study, students were given a 45-question pretest via the online Learning Management System. The system graded the exam, the teacher reviewed for any errors, and downloaded the results and provided them to the researcher. The following 20 days of the study were instructional days in which one treatment group received the gamified flipped instruction and the other received the flipped instruction, while the control group received a traditional lecture style class. On the 21st day of the study, the students took the final posttest via the online LMS system. Once again, the system graded the exam, the teacher reviewed for any errors, and downloaded the results and provided them to the researcher. The data extracted from the exams were stored on a password protected computer and used in Excel and SPSS. Student identities were protected using numeric codes assigned to each student throughout the duration of the study.

Test for Assumptions and Power

To compare the means and standard deviations of multiple groups when outcomes are utilized, researchers must satisfy the statistical assumptions of independence of observations, normality, and homogeneity of variance when three or more groups are involved. Since this was an experimental research design where each student was randomly placed in a group, the observations in each group are independent and are obtained by a random sample. This satisfies the independence of observation assumption. To test normality, the Shapiro Wilkes test was run on each of the variables to determine normality. Since there was a small sample size, determining the distribution of the variables of achievement, motivation, and engagement was important for choosing an appropriate statistical method. A Shapiro-Wilk test was performed and did not show evidence of non-normality Based on this outcome and after visual examination of the histograms of each variable and their respective Q-Q plots, it was decided that the One-Way ANOVA was the appropriate statistical test for interpreting the data.

Table 5

Tests of Normality

		Shapiro-Wilk		
	Student	Statistic	df	Sig
Pre-Test	Traditional	.959	23	.442
	Flipped	.953	23	.334
	Gamified Flipped	.937	23	.154
Post-Test	Traditional	.965	23	.580
	Flipped	.947	23	.252
	Gamified Flipped	.932	23	.119
Math Motivation Pre-Intervention	Traditional	.959	23	.438
	Flipped	.953	23	.334
	Gamified Flipped	.926	23	.089
Math Motivation Post-Intervention	Traditional	.967	23	.609
	Flipped	.952	23	.316
	Gamified Flipped	.931	23	.113
	Traditional	.934	23	.132
	Flipped	.965	23	.564

Student Engagement in Mathematics Pre-Intervention	Gamified	.979	23	.885
Student Engagement in Mathematics Post-Intervention	Traditional	.933	23	.126
	Flipped	.978	23	.860
	Gamified Flipped	.937	23	.158

Since the sample sizes are equal, the assumption of homogeneity is met, making all three assumptions true to run an ANOVA test. An *a priori* power analysis was conducted using G*Power version 3.1.9.7 (Faul et al., 2007) to determine the minimum sample size required to test the study hypothesis. Results indicated the required sample size to achieve 95% power for detecting a medium effect, at a significance criterion of $\alpha = .05$, was N = 66 for ANOVA testing. Thus, the obtained sample size of N = 69 is adequate to test the study hypothesis.

Research Question 1

Descriptive Analysis

The initial research question of this study focused on academic achievement scores. An examination of the Pre-Test Scores was conducted to determine if there were any differences between the three groups prior to the intervention.

Table 6

Descriptive Statistics for Pre-Test

	N	Mean	Std. Deviation	Std. Error	Minimum	Maximum
Traditional	23	25.04	13.25	2.76	.00	48.00
Flipped	23	28.09	13.70	2.86	.00	54.00
Gamified Flipped	23	26.87	17.88	3.73	.00	78.00
Total	69	26.67	14.92	1.80	.00	78.00

The One-way ANOVA test on the pre-test scores was not significant at the .05 level, $F(2,66) = .237$, $p = .790$. This indicated there was no significant difference between the groups prior to the intervention. To answer the first research question, the data for the post-test was examined. The mean, median, standard deviation, variance, minimum, maximum, and range of the posttest scores were calculated for both the treatment and control groups. Descriptive statistics for the treatment and control group posttests are presented in Table 7.

Table 7

Descriptive Statistics for Post-Test

	N	Mean	Std. Deviation	Std. Error	Minimum	Maximum
Traditional	23	50.61	23.30	4.86	.00	90.00
Flipped	23	48.96	20.13	4.20	22.00	90.00
Gamified Flipped	23	57.04	20.52	4.28	28.00	90.00
Total	69	52.20	21.34	2.57	.00	90.00

Inferential Analysis

A one-way between subjects ANOVA was conducted to compare the effect of Student Achievement between the traditional, flipped, and gamified flipped learning conditions. There was not a significant effect of academic achievement at the p>.05 level for the three conditions [F(2, 66) = .703, p = .499].

Table 8

One-Way Analysis of Variance in Post-Test Scores

	df	F	Sig.
Between Groups	2	.703	.499
Within Groups	66		
Total	68		

In addition to achievement from just post-test scores, it was important to see the adjusted post-test scores in relation to the pre-test scores. A one-way ANCOVA was conducted to compare the post-test scores of the three classes while controlling for the pre-test scores. Levene's test and normality checks were carried out and the assumptions met. There was not a significant difference in mean post-test scores [F(2,65)=1.023, p=0.365] between the post-test scores. Comparing the estimated marginal means showed that the gamified flipped classroom had the highest score (mean=56.94) compared to the flipped class and the traditional class (mean=48.40, 51.25 respectively).

Table 9

One-Way Analysis of Co-Variance in Post-Test Scores

Source	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	3	1050.76	2.46	.07	.10
Intercept	1	28184.00	65.90	<.001	.50
PRETEST	1	2312.51	5.41	.02	.08
Student	2	437.44	1.02	.37	.03
Error	65	427.71			
Total	69				
Corrected Total	68				

Table 10

Estimated Means of Post-Test Scores Factoring Pre-Test Scores

Student	Mean	Std. Error
Traditional	51.25[a]	4.32
Flipped	48.40[a]	4.32
Gamified	56.96[a]	4.31

Note: Covariates appearing in the model are evaluated at the following values: PRETEST = 26.6667.

Research Question 2

Descriptive Analysis

The second research question that guided this study regarded student motivation. To measure this, scores from the Math Motivation Questionnaire were compared from two instances: before the intervention and after the intervention. The questionnaire used a Likert scale response ranging from 1=Never to 5 = Always to respond to each prompt. An examination of the Pre-Intervention scores was conducted to determine if there were any differences between the three groups prior to the intervention.

Table 11

Descriptive Statistics of Math Motivation Questionnaire Pre-Intervention Data

	N	Mean	Std. Deviation	Std. Error	Minimum	Maximum
Traditional	23	3.12	.517	.108	1.73	4.30
Flipped	23	3.31	.471	.098	2.13	3.97
Gamified Flipped	23	3.30	.565	.118	1.73	4.17
Total	69	3.25	.517	.062	1.73	4.30

The one-way between subject ANOVA test was conducted and determined there was not a significant effect of academic achievement at the .05 level for the three conditions [F(2, 66) =

.761, p = .471]. This indicated there was no significant difference between the groups prior to the intervention.

Table 12

One-Way Analysis of Variance in Math Motivation Pre-Intervention

	df	F	Sig.
Between Groups	2	.761	.471
Within Groups	66		
Total	68		

To answer the second research question, the data for the MMQ post-intervention was examined. The mean, median, standard deviation, variance, minimum and maximum of the post treatment scores were calculated for both the treatment and control groups as shown in Table 13. For the traditional lecture group (n=23), the post treatment mean score was 3.38 with a standard deviation of .45 (SE=.09). The flipped group (n=23) produced a mean of 3.42 on the post treatment scores with a standard deviation of .56 (SE=.12). The gamified flipped group (n=23) had a mean score of 3.96 with a standard deviation of .40 (SE=.08). The maximum scores were 4.3 for the traditional group, 4.4 for the flipped group, and 5.0 for the gamified flipped group. The minimum score for the traditional group was 2.4, the minimum for the flipped group was 2.47, and the minimum for the gamified group was 3.43.

Inferential Analysis

The researcher conducted one way ANOVA's (analysis of variance) on the post intervention scores across all three groups of participants. Results indicated there was a significant difference [F(2, 66) = 10.63, p<.001] in the scores. Because a significant difference was found, a post-hoc test was done to determine the differences between the groups. Tukey's post hoc was performed since the groups are of equal sample sized. The Tukey's post-hoc analysis revealed that the gamified flipped classroom (M=3.96, SD=.56) motivation score was significantly different than the flipped (M=3.42, SD=.56) and traditional groups (M=3.39, SD=.45). There was no significant difference between the traditional and flipped group.

Table 13

Descriptive Statistics for Math Motivation Questionnaire Post-Intervention

	N	Mean	Std. Deviation	Std. Error	Minimum	Maximum
Traditional	23	3.38	.455	.099	2.40	4.30
Flipped	23	3.42	.556	.116	2.47	4.40
Gamified	23	3.96	.396	.082	3.43	5.00
Total	69	3.59	.536	.065	2.40	5.00

Table 14

One-Way Analysis of Variance in Math Motivation Questionnaire Post Intervention

	df	F	Sig.
Between Groups	2	10.63	<.001
Within Groups	66		
Total	68		

Table 15

Tukey HSD Summary for Math Motivation Questionnaire

(I) Student	(J) Student	Mean Difference (I-J)	Std. Error	Sig.
Traditional	Flipped	-.038	.140	.964
	Gamified	-.575*	.140	<.001
Flipped	Traditional	.038	. 140	.964
	Gamified	-.538*	. 140	.001
Gamified	Traditional	.575*	. 140	<.001
	Flipped	.538*	.140	.001

*. The mean difference is significant at the 0.05 level.

The makeup of the Math Motivation Questionnaire also allows for the evaluation of 6 different elements of motivation: intrinsic motivation, extrinsic motivation, personal relevance, self-determination, self-efficacy, and math anxiety. Table 16 shows a summary of each measure and the associated questions associated with each.

Table 16

Math Motivation Questionnaire Constructs

Construct	Question Numbers
Intrinsic Motivation (MMQPIM)	1, 16, 22, 27, 30
Extrinsic Motivation (MMQPEM)	3, 7, 10, 15, 17
Personal Relevance (MMQPPR)	2, 11, 19, 23, 25
Self-Determination (MMQPSD)	5, 8, 9, 20, 26
Self-Efficacy (MMQPSE)	12, 21, 24, 28, 29
Low Math Anxiety (MMQPLMA)	4, 6, 13, 14, 18

The researcher conducted one way ANOVA on each of the constructs across all three groups of participants. Results, as indicated in Table 17, demonstrate there were significant differences in 5 of the 6 constructs: intrinsic motivation , extrinsic motivation, personal relevance, self-determination, self-efficacy. There was no significant difference in the low math anxiety construct.. Figure 6 summarizes the data from each construct where a significant difference was indicated.

Table 17

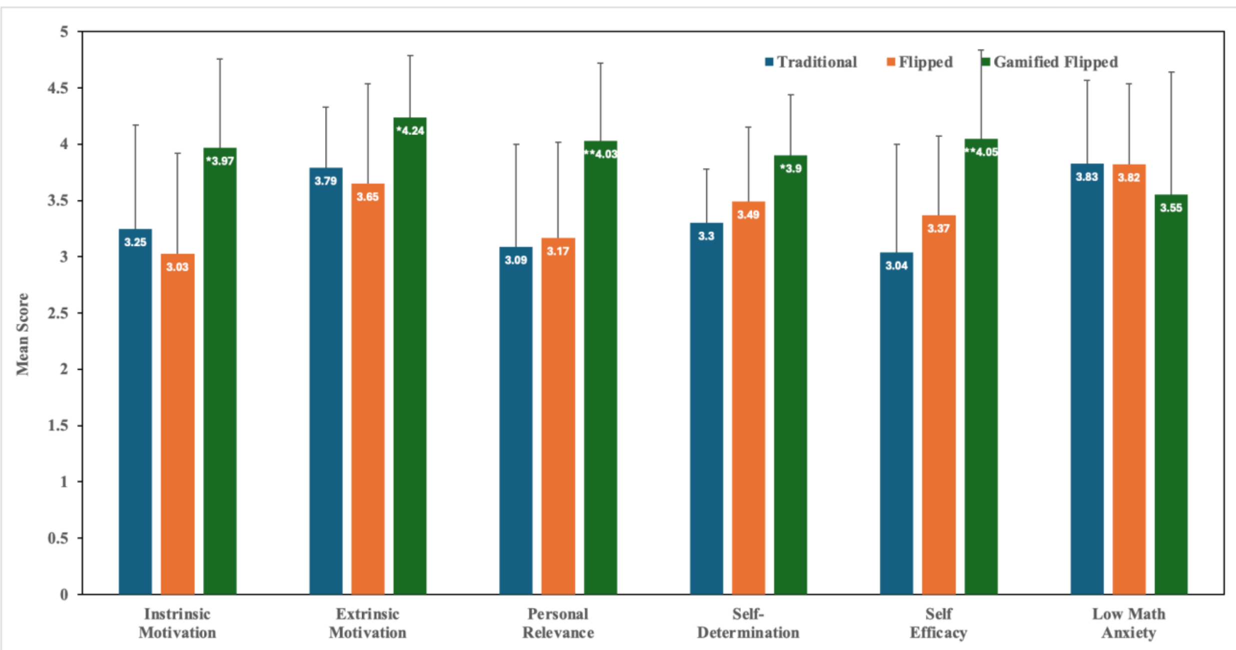
One-Way Analysis of Variance in Math Motivation Questionnaire Constructs

		df	F	Sig.
MMQPIM	Between Groups	2	7.152	.002
	Within Groups	66		
	Total	68		
MMQPEM	Between Groups	2	4.727	.012
	Within Groups	66		
	Total	68		
MMQPPR	Between Groups	2	9.443	<.001
	Within Groups	66		

	Total	68		
MMQPSD	Between Groups	2	7.029	.002
	Within Groups	66		
	Total	68		
MMQPSE	Between Groups	2	9.031	<.001
	Within Groups	66		
	Total	68		
MMQPLMA	Between Groups	2	.770	.467
	Within Groups	66		
	Total	68		

Figure 6

Tukey HSD Summary for Math Motivation Questionnaire Constructs



Note. Mean scores for the Math Motivation Questionnaire Constructs are shown for all three groups (error bars show standard deviation, * denotes p<.05, ** denotes p<.001)

Research Question 3

Descriptive Analysis

The third research question that guided this study pertained to student engagement. To measure this, scores from the Student Engagement in Mathematics Scale were compared from two instances: before the intervention and after the intervention. The questionnaire used a Likert scale response ranging from 1=No, not at all true to 4 = Yes, very true to respond to each prompt. An examination of the Pre-Intervention Scores was conducted to determine if there were any differences between the three groups prior to the intervention. The One-Way Between Subject ANOVA test was conducted and signified that there is no significant difference at the .05 level, $F(2,68) = .162$, $p = .851$ between the groups before the intervention. This indicated there was no significant difference between the groups prior to the intervention.

Table 18

Descriptive Statistics of Student Engagement in Mathematics Scale Pre-Intervention

	N	Mean	Std. Deviation	Std. Error	Minimum	Maximum
Traditional	23	2.40	.439	.091	1.77	3.15
Flipped	23	2.47	.439	.092	1.77	3.31
Gamified Flipped	23	2.42	.514	.107	1.46	3.54
Total	69	2.43	.460	.055	1.46	3.54

Table 19

One-Way Analysis of Variance in Student Engagement in Mathematics Scale Pre-Intervention

	df	Mean Square	F	Sig.
Between Groups	2	.035	.162	.851
Within Groups	66	.217		
Total	68			

To answer the third research question, the data for the Student Engagement in Mathematics Scale post intervention was examined. For the traditional lecture group (n=23), the post-treatment mean score was 2.45 with a standard deviation of .19 (SE=.04). The flipped group (n=23) produced a mean of 2.70 on the post treatment scores with a standard deviation of .49 (SE=.10). The gamified flipped group (n=23) had a mean score of 2.96 with a standard deviation of .48 (SE=.01). The maximum scores were 2.77 for the traditional group, 3.62 for the flipped group, and 3.62 for the gamified flipped group. The minimum score for the traditional group was 2.15, the minimum for the flipped group was 1.85, and the minimum for the gamified group was 2.08. Descriptive statistics for the treatment and control group engagement scores are presented in Table 20.

Table 20

Descriptive Statistics of Student Engagement in Mathematics Scale Post-Intervention

	N	Mean	Std. Deviation	Std. Error	Minimum	Maximum
Traditional	23	2.46	.195	.041	2.15	2.77
Flipped	23	2.70	.492	.103	1.85	3.62
Gamified Flipped	23	2.96	.481	.100	2.08	3.62
Total	69	2.70	.456	.055	1.85	3.62

Inferential Analysis

The researcher conducted one way ANOVA on each of the constructs across all three groups of participants. Results indicated there was a significant difference [$F(2, 66) = 8.382$, $p<.001$] in the scores. Because a significant difference was found, a post-hoc test was done to determine the differences between the groups. Tukey's post hoc was performed since the groups are of equal sample sized. The Tukey's post-hoc analysis revealed that the gamified flipped classroom (M=2.96, SD=.48) engagement score was significantly different than the traditional group (M=2.46, SD=.19), but none was found when compared to the flipped group. There was no significant difference between the traditional and flipped group.

Table 21

One-Way Analysis of Variance in Student Engagement in Mathematics Scale Post-Intervention

	df	Mean Square	F	Sig.
Between Groups	2	1.43	8.38	<.001
Within Groups	66	.170		
Total	68			

Table 22

Tukey HSD Summary for Student Engagement in Mathematics Scale Post-Intervention

(I) Student	(J) Student	Mean Difference (I-J)	Std. Error	Sig.
Traditional	Flipped	-.237	.121	.133
	Gamified Flipped	-.498*	.121	<.001
Flipped	Traditional	.237	.121	.133
	Gamified Flipped	-.261	.121	.089
Gamified Flipped	Traditional	.498*	.121	<.001
	Flipped	.261	.121	.089

*. The mean difference is significant at the 0.05 level.

The Student Engagement in Mathematics Scale also measures emotional engagement, social engagement, and cognitive engagement based on particular questions. Table 23 shows a summary of each measure and the associated questions associated with each.

Table 23

Student Engagement in Mathematics Scale Sub-Measures

Sub-Measure	Questions
Emotional engagement (SEMPEM)	6, 7, 8, 11, 12
Social engagement (SEMPSOC)	2, 3, 4, 5
Cognitive engagement (SEMPCOG)	1, 9, 10, 13

The researcher conducted one way ANOVA on each of the sub-measures across all three groups of participants. Results indicated there were significant differences in 1 of the 3 sub measures: social engagement [F(2, 66) = 6.709, p=.002], There was no significant difference in emotional engagement [F(2, 66) = 3.24, p=.05] and cognitive engagement [F(2, 66) = 1.88, p=.161]. A Tukey's post-hoc analysis revealed that the gamified flipped class (M=2.79, SD=.75) and the flipped class (M=2.65, SD=.82 had a significant different score in social engagement compared to the traditional (M=2.09, SD=.44) group.

Table 24

Descriptive Statistics of Student Engagement in Mathematics Scale Sub Measures

		N	Mean	Std. Deviation	Std. Error	Minimum	Maximum
SEMPEM	Traditional	23	1.31	.430	.090	.40	2.00
	Flipped	23	1.36	.644	.134	.40	2.80
	Gamified Flipped	23	1.69	.539	.112	.80	2.80
	Total	69	1.45	.562	.068	.40	2.80
SEMPSOC	Traditional	23	2.09	.443	.092	1.25	3.00
	Flipped	23	2.65	.825	.172	1.00	4.00
	Gamified Flipped	23	2.79	.749	.156	1.75	4.00
	Total	69	2.51	.748	.090	1.00	4.00
SEMPCOG	Traditional	23	3.00	.494	.103	2.25	3.75
	Flipped	23	3.13	.568	.119	2.00	4.00
	Gamified Flipped	23	3.32	.595	.124	2.25	4.00
	Total	69	3.15	.561	.066	2.00	4.00

Table 25

One-Way Analysis of Variance in Student Engagement in Mathematics Scale

		df	F	Sig.
SEMPEM	Between Groups	2	3.24	.045
	Within Groups	66		
	Total	68		
SEMPSOC	Between Groups	2	6.71	.002
	Within Groups	66		
	Total	68		
SEMPCOG	Between Groups	2	1.88	.161
	Within Groups	66		
	Total	68		

Table 26

Tukey HSD Summary of Student Engagement in Mathematics Scale Sub Measures

Dependent Variable	(I) Student	(J) Student	Mean Difference (I-J)	Std. Error	Sig.
SEMPEM	Traditional	Flipped	-.043	.161	.960
		Gamified Flipped	-.374	.161	.059
	Flipped	Traditional	.043	.161	.960
		Gamified Flipped	-.330	.161	.107
	Gamified Flipped	Traditional	.374	.161	.059
		Flipped	.330	.161	.107
SEMPSOC	Traditional	Flipped	-.565*	.204	.020
		Gamified	-.707*	.204	.003
	Flipped	Traditional	.565*	.204	.020
		Gamified Flipped	-.141	.204	.769
	Gamified Flipped	Traditional	.707*	.204	.003
		Flipped	.141	.204	.769
SEMPCOG	Traditional	Flipped	-.130	.163	.705
		Gamified	-.315	.163	.139
	Flipped	Traditional	.130	.163	.705
		Gamified Flipped	-.185	.163	.499
	Gamified Flipped	Traditional	.315	.163	.139
		Flipped	.185	.163	.499

*. The mean difference is significant at the 0.05 level.

CHAPTER 5. CONCLUSION

This research studied the effects of a gamified flipped classroom on student achievement, motivation, and engagement in a summer high school mathematics class. In the gamified flipped class sections, Classcraft was utilized to gamify the activities within the flipped classroom setting, which included the use of online videos of lectures watched by students outside of class time. Students would then work in class on inquiry-based and collaborative group work assignments, which include what is traditionally thought of as homework. The accessible population in this study were all students participating in a summer academic enrichment program during the summer of 2023. Participants in the intervention group were one section of students using the gamified flipped classroom method. There was additionally one section of students using the flipped classroom method. The control group was one section taught using the traditional method of lecture and homework. The dependent variables used for this study were achievement scores from the post-test in each class, the scores from the Math Motivation Questionnaire, and scores from the Student Engagement in Mathematics Scale. The theoretical framework for the study was Self-Determination Theory. Deci and Ryan (2017) contend that in order to enhance student motivation, the components of competence, autonomy, and social relatedness must be present. This study may contribute to positive change in education, as it provides a research-based foundation drawn from a high school mathematics setting that assesses the benefits of utilizing gamification along with the flipped classroom setting for student achievement, motivation, and engagement. This chapter will discuss and summarize the results and deliberate the limitations of the study. The implications for teaching and recommendations for practice will be explored, followed by recommendations for further research.

Summary of Major Findings

The population for this study consisted of 69 students. This study originated with 69 students participating in a summer academic enrichment program. There were 23 students in the traditional lecture class, 23 students in the flipped class, and 23 students in the gamified flipped class. Research Question 1 asked “How do students’ achievements differ between traditional, flipped, and gamified flipped instructional models as measured by post-test scores?” The findings of the study indicated that though the gamified flipped class’s mean was higher, there was no significant difference in the post-test scores between the three groups. The growth mean scores (post-test scores minus pre-test scores) indicated that the gamified flipped class demonstrated the largest growth from pre-test to post-test.

Research Question 2 asked, “How does student motivation differ between traditional, flipped, and gamified flipped instructional models as measured by scores from the Math Motivation Questionnaire?” The findings from this study indicated there was a significant difference in the MMQ scores amongst the three groups. Tukey’s Post Hoc test indicates that the gamified flipped class motivations core was significantly different than the flipped class and the traditional class. Further, within the 6 motivation constructs measured by the MMQ (intrinsic motivation, extrinsic motivation, personal relevance, self-determination, self-efficacy, and math anxiety), results indicated that apart from math anxiety, there was a significant difference between the three groups. The gamified flipped class had a significant difference over the traditional and flipped class in internal motivation, external motivation, self-determination, personal relevance, and self-efficacy.

Research Question 3 asked, “How does student engagement differ between traditional, flipped, and gamified flipped instructional models as measured by the Student Engagement Scale in Mathematics?” The findings indicated that there was a significant difference in the Student Engagement in Mathematics Scale scores amongst the three groups. Tukey’s post hoc analysis indicated that the gamified flipped class scores were significantly different than the flipped and traditional class scores. Also, 3 sub measures (Emotional Engagement, Social Engagement, Cognitive Engagement) were analyzed and a significant difference was found within the Social Engagement sub measure. Tukey’s post hoc analysis determined that the gamified flipped and the flipped class had significantly higher Social Engagement scores compared to the traditional class.

Discussion

This research was used to investigate if the use of Gamification within a flipped classroom would enhance students' academic achievement, motivation, and engagement within Mathematics. The addition of gamification to the flipped classroom in this study was intended to address some of the drawbacks of the flipped classroom. In a gamified system, the notion of 'challenge' significantly contributes to good learning outcomes (Sánchez-Martn, Caada-Caada, and Dávila-Acedo, 2017). In addition to integrating learning with interactivity and interest, challenges that are surmounted inspire students to learn more by fostering a sense of accomplishment. These challenges serve as explicit objectives, aiding students in concentrating their endeavors. Moreover, engaging in the process of confronting challenges provides students with valuable feedback, which enables them to pinpoint specific areas that require enhancement. As reported in some studies (Huanget al., 2019; Jagut, Botiki, & So, 2018; Jo, Jun, & Lim, 2018; Lo & Hew, 2018; Zainuddin, 2018), integrating this concept into contemporary pedagogical instruction such as flipped learning could be an alternative and effective strategy to enhance students' learning achievement. The desired results would indicate that student engagement was increased through the use of gamification, as evidenced by higher achievement scores and greater learning gains compared to students who did not utilize gamification. The effective incorporation of the gamification framework into the curriculum with the aim of enhancing students' motivation, academic performance, and attitudes towards lessons constitutes the gamification of educational processes (Yildirim, 2017).

Chen et al. (2018) stated, "Gamified active learning has been shown to increase students' academic performance and engagement and help them make more social connections than standard course settings." In this study though the students in the gamified flipped class had a higher mean score on the post-test than the other groups, the results were not statistically significant. The learning gains for each group (post-test scores minus pre-test scores) demonstrated greater mean growth in the gamified flipped class than the flipped and traditional class. Given the academic rigors of the summer program (5 Core Classes and 1 Elective Class), this may have had an impact on the student and their academic achievement. The students undertake this program 2 weeks after the conclusion of their high school academic year. It is possible that academic fatigue and high cognitive load may have played a role in the lack of statistical significance within academic achievement, though the mean scores for the gamified class was higher. This study being conducted during the normal high school academic setting and year may yield different results.

Motivation and engagement, conceptualized as students' energy and drive to participate, learn, work efficiently, and realize their potential at school, play a significant impact in students' interest in school and academic success (Martin, 2006; Martin, 2001; Martin & Marsh, 2003). Regarding motivational outcomes, a statistically significance was found between the three groups using the Math Motivation Questionnaire (MMQ). The gamified flipped class demonstrated higher levels of motivation than both the flipped and traditional classes, which demonstrates the positive effect a gamified quiz with points and team leaderboards can have on motivation. This result is in line with research demonstrating gamification having positive effects on motivation within education (Sailer & Homner, 2020; Subhash & Cudney, 2018; Raes et al., 2020). This suggests that an effective gamification design (The effective utilization of Classcraft) aims to comprehend and connect the learning goals with the inherent motivation of the learner. The ability of the instructor to clearly relate each activity with the learning goal and providing students with instant feedback was implemented in the course, following the suggested effective gamification design.

The MMQ also evaluated six constructs to further examine motivation. The study found that the gamified class had a statistically significant difference within 5 of the 6 constructs. With regards to extrinsic motivation, the use of a gamified environment, including rewards and leaderboards, providing students with incentives to keep them externally motivated. The inter-team and interpersonal challenges that took place also contributed to the positive learning outcomes within the class (Sánchez-Martin, Caada-Caada, and Dávila-Acedo, 2017). The instructor ensured that students had a clear sense of purpose within each class regarding the gamified elements and tying them to the learning objectives. Margolis & McCabe (2010) discussed how encouraging students to learn new skills and attempt challenges that are new to them is a keyway to improve self-efficacy, especially within struggling students. This concept was infused within the gamified flipped class environment by the instructor, particularly when new concepts were being introduced to the class to help build self-efficacy. In their study, Buil et al. (2020) employ empirical evidence and Self-Determination Theory (SDT) to illustrate the successful integration of multiple game design components that satisfy students' requirements for autonomy, relatedness, and competence. Gamification effectively raises student engagement in a course by promoting active participation through the use of digital mechanisms such as badge accumulation and competition for highest scores (Barata, 2017; Baydas & Cicek, 2019). The gamified reversed class achieved a notable score of self-determination on the MMQ, which provides support for this claim.

Psychological need satisfaction may be impacted by gamification-induced modifications to the learning environment (Sailer et al., 2017). When considering major encounters, the requirements for competence and social connectedness become pertinent. Through the individual conflicts, this evaluation allowed students to demonstrate their comprehension and mastery of a specific concept. Through collaborative combat, students not only assessed their own understanding and proficiency but also collaborated with their peers to exhibit their collective comprehension and cohesion. Each individual was responsible for a portion of the battle (conflict) but could seek assistance from their colleagues. Emotions of effectiveness and achievement in engaging with the educational setting are associated with the psychological need for competence (Vansteenkiste & Ryan, 2013). To fulfill this requirement, various forms of feedback can be implemented, such as the utilization of points during enemy encounters (Rigby & Ryan, 2011). Shared objectives satisfied the need for social relatedness, which pertains to a sense of affiliation and attachment to a group, (one team watched the videos together to ensure their notes were comprehensive enough to score maximum points for their team and the individuals on their team) and agreed outcomes in the game (one team always made a group decision when a character wanted to or needed to use their powers) or through the team leaderboard in Classcraft (Sailer et al., 2017). Making education relevant to students' lives (current and future) should result in increased learning and engagement (Hulleman and Harackiewicz, 2009). Students enjoy a subject more when they perceive the content to be relevant (Smart and Rahman, 2008). This was evidenced by the increase in personal relevance on the MMQ in the gamified flipped class. The instructor further emphasized the personal relevance to real world applications that was originally introduced in the video to the gamified flipped class. There was also a game associated with teams demonstrating a real-life application of certain concepts. There was not a significant difference in Low Math Anxiety, which supports the lack of research in how altering the learning environment can assist in decreasing low math anxiety.

Engaged students exert more effort, experience more good emotions, and pay greater classroom attention (Fredricks, Blumenfeld, & Paris, 2004). Additionally, participation has been linked to improved student outcomes, such as higher grades and fewer dropouts (Connell, Spencer, & Aber, 1994). Teachers and the learning environment created plays a crucial impact in the engagement and motivation of their students (Hill & Rowe, 1996). The study demonstrated that the gamified flipped classroom did have a significant difference over the traditional class. Further evaluation of the 3 sub measures showed that a significant difference within the social engagement sub measure. This would follow with the social aspect combined with the team game aspect of a gamified flipped classroom. The flipped classroom methodology frees up class time for students' active engagement in activities facilitated by their classmates and the teacher. The gamification in this study was designed so students would work in teams both in and out the classroom. This was a measure designed to ensure the students need for social relatedness was met, according to Self-Determination Theory. Much of the gamified flipped class time was spent within their teams and helping each other with mastery of the topics and with the game activities within the class. This action was not as prevalent within the normal flipped class, though students did help each other. There was no team play within that class. Several studies on gamification emphasize the lack of intrinsic motivation over extrinsic motivation (Hamari & Koivisto 2012, Nicholson 2012, Marache-Francisco & Brangiers 2015). This attitude may stem from the fact that while both extrinsic and intrinsic motivation enhance performance gains, only intrinsic motivation has been linked to improved psychological well-being, increased creativity and learning outcomes, as well as higher levels of effort put into a task (Mekler et al., 2017).

However, this study is a start to show that external and intrinsic motivation may not be mutually exclusive and possibly could have a mutually beneficial relationship. The use of external motivating factors in gamification can lead to higher levels of intrinsic motivation and engagement. Further research could explore ways to increase cognitive and emotional engagement with the mathematics class using the gamified flipped classroom method.

Implications

Certain researchers have demonstrated that the implementation of gamification and the flipped classroom approach can generate positive effects on student achievement, motivation, and engagement in the subject of mathematics. However, the program for combining multiple uses into one class is not universal. Before implementing this strategy, it is advisable for the school or faculty to ascertain that the instructor possesses a comprehensive comprehension of the flipped classroom approach and gamification. It is strongly advised that the instructor participate in a professional development series or training program pertaining to both subjects (Parra-González et al., 2021). In order to effectively integrate flipped gamification into the classroom environment, conventional classroom layouts must be reconfigured to facilitate concurrent and standardized learning of all subject matter by all students. Complete gamification entails the implementation of a gamification design in its entirety. Within a specified time period, students can acquire mastery of skills through both independent and collaborative group work in a fully gamified classroom. Certain pupils may exhibit rapid progress in this environment, whereas others may progress more slowly and necessitate further time for practice. Learning in a gamified environment is not intended to improve learning pace, but rather learning effectiveness. Academic pressure is placed on students to acquire proficiency in a series of skills and ideas within a designated period of time, such as a semester or quarter. Opportunities are made available to students to implement the knowledge that they have gained.

As indicated by research, for gamification to be effective, learning objectives must be precisely aligned with game components according to a meticulously designed strategy. Suchers et al. (2017) state the following: “An understanding of the overarching notion of gamification enables its deconstruction into more specific elements and temporal intervals.” Providing an indefinite number of lives is an advantageous design approach that may aid pupils who necessitate additional time to attain proficiency. Establishing a game-like environment is dependent on a cursory understanding of numerous gamification techniques. Research indicates that relying solely on points and certificates for student motivation may not be adequate, and in fact, it may even have the opposite effect on certain students (Balci et al., 2022). This limitation falls beyond the purview of the research and carries ramifications for designers. Educators are restricted to employing readily available technological resources unless they possess the capability to create applications. This is an actual concern regarding gamification. Elevated school students demonstrate an enhanced level of refinement and comfort when participating in complex games. Smartphone application games, online games, and PC games have all contributed to the intellectual development of the typical high school student. Papastergiou (2009) states that incorporating technology-based programs into a gamified learning environment requires the implementation of comprehensive gamification. Educators who program and code must understand the fundamentals of game design and be able to incorporate them into gamification solutions. It is vital that designs utilized in gamification technology are both age-appropriate and captivating. Before deciding which technological instrument to use to define the boundaries of a gamified classroom, lesson, or project, instructors must have a thorough understanding of game design characteristics. An instrument ought not to be discarded merely on the basis that it is user-friendly or convenient for the instructor. For gamification to have an effect on learning, it is imperative that gamification technologies exert a significant influence on students' learning. The study suggests that educators should not only acquire proficiency in utilizing technology through software or applications, but also develop the ability to incorporate it into a more comprehensive understanding of the foundational principles of gamification.

This underscores the significance of TPACK in teacher preparation, placing emphasis on the notion that educators must possess not only technological proficiency but also the ability to seamlessly incorporate it with pedagogical approaches and their particular subject matter. While technology does improve convenience, it is not a prerequisite for the full implementation of gamification. It is critical to comprehend game designs and game features in order to generate effective gamification concepts. The second objective is to provide students with a comprehensive orientation concerning the learning environment. This is a drastically different environment that could be detrimental to students' academic performance if they are not adequately prepared for it or provided with a guide on how to succeed. Ensuring the monitoring of students' progress in all three domains—achievement, motivation, and engagement—is critical to the success of this endeavor. This can be accomplished with the aid of summative and formative evaluations that are consistent with the pre-test instrument and the gamification program. To gauge students' motivation and engagement prior to and after class, brief surveys or even daily emoticons should be utilized. This will aid the instructor in determining how to optimize the learning environment for the students. (Theoretical Application, with a specific focus on Motivation Theory, intrinsic and extrinsic factors, and Self-Determination Theory)

Limitations of the study

This study faced a few limitations. The first limitation was the small sample size. While the sample size met the power requirements at .5 size effect, the study could show even greater effect with a larger sample size. Even though the current sample size was sufficient to detect a statistically significant effect (0.5 effect size) in motivation and engagement, a larger sample size could provide a more accurate picture of how much the gamified flipped class actually impacts the outcomes being measured. With a larger sample size, the study might find the same magnitude of effect (0.5) but with a higher level of statistical significance. This could provide a more precise estimate of the existing effect and strengthen the statistical significance of the findings. The length of time for the study was also a limitation. This study was conducted over a 6-week period. This length of time is only a fraction of the normal school semester. A greater amount of time would allow the students more time to get accustomed to the learning environment and for the researcher to have more research data points. Another limitation was the grade level of the students varied, which could have affected the way the students were able to handle each environment. The grade levels ranged from rising 10th grade and rising 11th grade. Those who were in the rising 11th grade had two full years of experience in high school over those who were just completing their first year. This gave the older students a potential advantage in experience in the classroom at the high school level. Students in higher grade levels (rising 11th grade) may have inherently more motivation and even engagement levels, based on having more high school experience, over rising 10th graders In addition, for some, it was their first summer within the summer program and others had previous experience. These new students were getting accustomed to the summer program summer program environment, which included living away from home on a college campus, taking new classes, and other new environmental factors. Having to deal with all these factors, especially for those younger students, could influence how they handled the classroom environment. Also, the time of the year of the study may have been another limitation. The summer session, which occurs 2 weeks after the end of the regular semester, may not allow for rest (especially cognitive) from the end of school. Students may be coming into the summer program with some fatigue. This study was conducted within a rigorous summer program involving 5 core and 1 elective class. Students' academic fatigue and high cognitive load from this demanding schedule may have impacted their academic achievement in the program. Ideally, this would be done during the school year, where students are in the academic mindset. These limitations of this study, though a good start, may make the generalizations of the findings difficult.

Future Research Recommendations

More investigations are needed on the implementation of the gamified flipped classroom model by additional educational institutions. In educational settings, scholars have advocated for a pedagogical approach whereby students are not just directed to passively observe or acquire knowledge outside of the classroom but are also actively motivated to engage with the subject matter (Lee & Hannafin, 2016). The use of gamification in the context of the flipped classroom could be that answer as it fosters the acquisition of knowledge prior to class, the development of students' ability to study independently, and the cultivation of critical thinking abilities in students. There has been much research undertaken on the intrinsic motivation of students in the context of online community learning or similar environments. The topic under consideration is the field of emerging technologies. Therefore, it is advisable to do more research to investigate and analyze the extrinsic motivation of students from a self-determination perspective. The focus of this study is in the realm of theory, specifically pertaining to the domains of gamification and flipped classroom research and the progression of pupils' extrinsic motivation to intrinsic motivation. Future researchers should also consider any difficulties or issues that may relate to the existing design. Future research designs should include the measurement of students' backgrounds, acquiring motivation and engagement prior to commencing the lessons. Teachers may customize their teaching environment to better accommodate each student by comprehending their backgrounds. This may include modifying the complexity of the content, offering extra assistance to challenging students, or integrating several learning modalities into their teaching. Identifying the most predictive variables of student achievement may lead to the development of more effective treatments for challenging students. By understanding how student background, motivation, and engagement affect learning, teachers can develop more effective teaching practices. This can lead to improved student outcomes for all students (Williams & Williams, 2011). In conclusion, it is strongly advised that further research be conducted to better investigate the comparison between the gamified-flipped, flipped only, gamified only, and non-gamified, non-flipped classroom approaches. The differences observed will give the impact of the pedagogical design.

Summary

Math is a challenge for high school students in the United States, particularly first generation, low-income students. A different instructional methodology may assist in reversing this issue. The flipped classroom has shown major promise in assisting in motivating and engaging students in classrooms. However, more is needed to maximize that learning environment. According to de Araujo et al. (2017), it is essential to use a novel approach inside the flipped classroom setting to enhance students' comprehension of audiovisual materials or information prior to class. A re-design of the standard flipped classroom deployment is necessary. An alternative approach to the traditional flipped classroom paradigm necessitates the incorporation of an additional inventive method, such as the integration of gaming aspects. Although educators have access to a wide range of resources at their disposal, there are still gaps in knowledge on how to utilize them correctly and efficiently.

Since gamification and the flipped classroom is a rapidly expanding area of research, there is still much to learn about how to apply both concepts effectively in the classroom. Even though gamification techniques are widely used, much remains to be learned about their efficacy. To verify the different components and game concept, further research must be created and carried out. Given how pervasive technology is, additional tools will surely be created in the future, and study into how and if they work will always be necessary. To apply best practices, educators must arm themselves with an understanding of what the flipped classroom method and gamification is and is not. In the flipped classroom space, more training is needed on the development of high-quality instructional videos and the proper usage of the in-class time by the instructor. To integrate game theory with pedagogy, this researcher suggests that software developers and instructors work together. Combining these two potent fields of study may therefore provide gamification tool users with the pedagogy and technology they need to successfully execute their approach. Upcoming studies will confirm recommended procedures and practical uses. If educators are going to utilize the tools, then it is their responsibility to comprehend creating a flipped classroom game design and the best ways to apply it in the classroom.

This study's findings did contribute to the growing body of information about the motivation and engagement in a gamified flipped class. As gamification develops as a field, more details on its efficacy will be found as data and studies are added to the corpus of knowledge. This study confirms that further research is necessary to determine the most effective ways to develop and implement a gamified flipped classroom. Research still lacks a thorough methodology that takes into instructional video creation, game design, the impact of individual components, and the subject matter. Since gamification technologies are becoming more and more popular in education, educators need to learn how to utilize them properly if they want to use gamification as a motivating and engagement tool. Many studies don't make it obvious which specific factors are being looked at in relation to the intended results (Landers et al., 2018). It's critical to recognize game components, their effects, and the combinations in which they work best (Landers et al., 2018). Gamification should be used as a tool to address certain issues and provide challenges in the classroom, not as a collection of components assembled just for entertainment purposes or to apply technology (Dichev et al., 2015). For a gamified flipped classroom to really serve as an effective learning methodology, its design must go beyond watching a simple premade video, leaderboards, and points to foster true learning (Chia & Hung, 2017).

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Appendix A. Math Motivation Questionnaire

The items in the questionnaire are (choices include Never, Rarely, Sometimes, Usually, or Always):

1) I enjoy learning math.

2) The math I learn relates to my personal goals.

3) I like to do better than the other students on the math tests.

4) I am nervous about how I will do on the math tests.

5) If I am having trouble learning the math, I try to figure out why.

6) I become anxious when it is time to take a math test.

7) Earning a good math grade is important to me.

8) I put enough effort into learning the math.

9) I use strategies that ensure I learn math well.

10) I think about how learning math can help me get a good job.

11) I think about how the math I learn will be helpful to me.

12) I expect to do as well as or better than other students in the math course.

13) I worry about failing math tests.

14) I am concerned that the other students are better in math.

15) I think about how my math grade will affect my overall grade point average.

16) The math I learn is more important to me than the grade I receive.

17) I think about how learning math can help my career.

18) I hate taking the math tests.

19) I think about how I will use math I learn.

20) It is my fault if I do not understand math.

21) I am confident I will do well on math assignments and projects.

22) I find learning math interesting.

23) The math I learn is relevant to my life.

24) I believe I can master the knowledge and skills in the math course.

25) The math I learn has practical value for me.

26) I prepare well for math tests and quizzes.

27) I like math that challenges me.

28) I am confident I will do well on math tests.

29) I believe I can earn a grade of "A" in the math course.

30) Understanding math gives me a sense of accomplishment.

Appendix B. Student Engagement in Mathematics Scale

Student Engagement in Mathematics

We are interested in your thoughts about math class today. Please read each statement, and circle the number that fits.

Statement	No, not at all true	A little true	Often true	Yes, very true
1. Today in math class I worked as hard as I could.	1	2	3	4
2. Today I talked about math to other kids in class.	1	2	3	4
3. Today I helped other kids with math when they didn't know what to do.	1	2	3	4
4. Today I shared ideas and materials with other kids in math class.	1	2	3	4
5. Students in my math class helped each other learn today.	1	2	3	4
6. Math class was fun today.	1	2	3	4
7. Today I felt bored in math class.	1	2	3	4
8. I enjoyed thinking about math today.	1	2	3	4
9. Today it was important to me that I understood the math really well.	1	2	3	4
10. I tried to learn as much as I could in math class today.	1	2	3	4
11. Learning math was interesting to me today.	1	2	3	4
12. I liked the feeling of solving problems in math today.	1	2	3	4
13. I did a lot of thinking in math class today.	1	2	3	4