

**The Impact of Gamified Learning Strategies on Student Achievement in
Algebra and the Fundamentals of Analysis**

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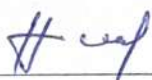
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List of Abbreviations

APA — American Psychological Association

ENT — Unified National Testing

GAMEFULQUEST — Gameful Experience Questionnaire

GPA — Grade Point Average

H1 — First hypothesis

H2 — Second hypothesis

ID — Identification code

MCQ — Multiple-choice question

OECD — Organisation for Economic Co-operation and Development

PISA — Programme for International Student Assessment

SD — Standard deviation

SDT — Self-Determination Theory

STEM — Science, Technology, Engineering, and Mathematics

TIMSS — Trends in International Mathematics and Science Study

ZPD — Zone of Proximal Development

ABSTRACT

This study examined the impact of gamified learning strategies on Grade 10 students' achievement in Algebra and the Fundamentals of Analysis and explored students' perceptions of the gamified learning experience. A quantitative quasi-experimental design was used with 58 tenth-grade students from one school in Kazakhstan, including 29 students in the experimental group and 29 students in the control group. The intervention focused on derivative-based topics, including critical points, extrema, monotonicity, intervals of increase and decrease, and maximum and minimum values.

A 25-item multiple-choice achievement test was administered before and after the intervention to measure students' achievement. Students' perceptions were measured using the GAMEFULQUEST questionnaire, which was completed by the experimental group after the intervention. The results showed that both groups improved from pre-test to post-test; however, the experimental group demonstrated greater improvement. The experimental group's mean score increased from 10.28 to 17.52, while the control group's mean score increased from 10.52 to 12.59. The post-test comparison showed a statistically significant difference in favor of the experimental group, $t(56) = 5.27$, $p < .001$, with a large effect size, Cohen's $d = 1.38$. GAMEFULQUEST results indicated generally positive perceptions of the gamified learning experience, especially in the dimensions of Accomplishment and Guidance. The findings suggest that gamified learning strategies can support student achievement and create a positive learning experience in upper-secondary mathematics classrooms.

Keywords: gamification, mathematics education, Algebra and the Fundamentals of Analysis, student achievement, quasi-experimental design, GAMEFULQUEST.

АНДАТПА

Бұл зерттеуде геймификацияланған оқыту стратегияларының 10-сынып оқушыларының «Алгебра және анализ бастамалары» пәні бойынша оқу жетістіктеріне әсері және оқушылардың геймификацияланған оқытуды қабылдауы қарастырылды. Зерттеу геймификацияланған оқыту дәстүрлі оқыту әдістерімен салыстырғанда жоғары нәтижеге ықпал ете ме және оқушылар оны оң қабылдай ма деген сұрақтарға жауап беруге бағытталды.

Зерттеуде сандық квазиэксперименттік дизайн қолданылды. Оған Қазақстандағы бір мектептің 58 оныншы сынып оқушысы қатысты: 29 оқушы эксперименттік топқа, 29 оқушы бақылау тобына енгізілді. Интервенция туындыны қолдануға байланысты тақырыптарға, атап айтқанда кризистік нүктелер, экстремумдар, монотондылық, өсу және кему аралықтары, сондай-ақ функцияның ең үлкен және ең кіші мәндерін табуға негізделді. Деректерді жинау үшін интервенцияға дейін және кейін 25 тапсырмадан тұратын оқу жетістіктері тесті өткізілді, ал эксперименттік топ оқушылары GAMEFULQUEST сауалнамасын толтырды. Эксперименттік топтың орташа нәтижесі 10.28-ден 17.52-ге дейін, ал бақылау тобының орташа нәтижесі 10.52-ден 12.59-ға дейін артты. Пост-тест нәтижелері бойынша топтар арасында статистикалық тұрғыдан маңызды айырмашылық анықталды: $t(56) = 5.27$, $p < .001$, Cohen's $d = 1.38$. Алынған нәтижелер геймификацияланған оқыту оқу жетістіктерін арттыруға және математика сабағында құрылымды әрі оқушыны белсенді қатысуға ынталандыратын оқу тәжірибесін қалыптастыруға ықпал ете алатынын көрсетеді.

Түйінді сөздер: геймификация, математикалық білім беру, Алгебра және анализ бастамалары, оқушылардың оқу жетістігі, квази-эксперименттік дизайн, GAMEFULQUEST.

АННОТАЦИЯ

В данном исследовании рассматривалось влияние геймифицированных стратегий обучения на учебные достижения учащихся 10 класса по предмету «Алгебра и начала анализа», а также изучалось восприятие учащимися геймифицированного обучения. Исследование было направлено на выяснение того, способствует ли геймифицированное обучение более высоким результатам по сравнению с традиционными методами преподавания и воспринимается ли оно учащимися положительно. В работе был использован количественный квазиэкспериментальный дизайн. В исследовании приняли участие 58 учащихся 10 класса одной школы в Казахстане: 29 учащихся вошли в экспериментальную группу и 29 в контрольную группу. Интервенция была основана на темах, связанных с применением производной, включая критические точки, экстремумы, монотонность, промежутки возрастания и убывания, а также наибольшие и наименьшие значения функции.

Для сбора данных был проведен тест учебных достижений из 25 заданий до и после интервенции, а учащиеся экспериментальной группы заполнили опросник GAMEFULQUEST. Средний результат экспериментальной группы повысился с 10.28 до 17.52, тогда как в контрольной группе с 10.52 до 12.59. Различие между группами по результатам пост-теста оказалось статистически значимым: $t(56) = 5.27$, $p < .001$, Cohen's $d = 1.38$. Полученные результаты показывают, что геймифицированное обучение может способствовать повышению учебных достижений и созданию более организованного и вовлекающего опыта изучения математики.

Ключевые слова: геймификация, математическое образование, Алгебра и начала анализа, учебные достижения учащихся, квазиэкспериментальный дизайн, GAMEFULQUEST.

1. INTRODUCTION

1.1 Background and Significance of the Study

Mathematics plays an important role in modern education as it helps students develop abstract thinking, logical reasoning, and problem-solving skills. In upper-secondary education in Kazakhstan, Algebra and the Fundamentals of Analysis is one of the key subjects for Grades 10 and 11. This course includes advanced topics such as functions, trigonometric equations, exponential and logarithmic relationships, limits, derivatives, and the basic integral calculus. Therefore, success in this subject is important not only for school performance, but also for students' future studies, especially in STEM-related fields (Bettinger & Long, 2009; Sadler & Tai, 2007).

However, in recent times it can be noticed that many students find Algebra and the Fundamentals of Analysis difficult. New 10th-graders often have gaps in their prior mathematical knowledge, making it difficult to understand more abstract concepts like limits and derivatives. Furthermore, the pressure from exams and academic expectations can reduce students' confidence and interest in mathematics. As a result, some students begin to rely on memorization rather than real understanding, which can lead to lower motivation and mathematics anxiety (Ashcraft & Moore, 2009; Hannula, 2002; OECD, 2023). According to the 2022 Programme for International Student Assessment (PISA), a significant number of 15-year-old students across Eastern Europe and Central Asia report low confidence in their abilities in mathematics, with negative attitudes toward the subject especially common among students from lower socioeconomic backgrounds (OECD, 2023).

These challenges have encouraged mathematics educators and researchers to explore different teaching approaches that can improve students' academic achievement, motivation, and participation. One of the approaches that has attracted increasing attention in recent years is gamification - the use of game elements and mechanics in non-game educational settings (Deterding et al., 2011). Gamification can include a variety of instructional strategies, such as points, badges, leaderboards,

escape-room activities, and role-play tasks. Although these approaches may differ in format, they share a common goal: using elements of games such as challenge, feedback, progression, choice, and social interaction to create a more engaging learning environment and encourage students to become more actively involved in mathematics learning.

Nowadays, the purpose of education is not only to equip students with a certain amount of knowledge, but also to gain skills and personal qualities that allow them to separately solve various cognitive tasks. It is known that a student should not only learn in the learning process, but also set goals, organize their work, and be resourceful. For this, it is essential to intensify the student's desire to learn (Baymyrzayev et al., 2023)

To upgrade the quality of education, demands a continuous pursuit and integration of innovative forms and methods of teaching. This shift manifests in modern pedagogical practices using interactive mode; students' interest in the subject allows explaining new teaching methods to them, to form important skills necessary for socialization (Oteniyazov, 2023). The use of interactive pedagogical approaches can help promote student engagement in the learning process (Muir et al., 2022). One area that notably requires innovative approaches is mathematics - a subject that, despite its importance, is often associated with difficulty and lack of interest on the part of learners. As Umay (2002) said: "Games are mostly mathematics and mathematics is completely game" because of this, we chose gamification as it is one of the most effective pedagogical approaches (Werbach, 2014). Gamification is often used as an acceptable strategy in order to expand the recognition and attractiveness of a particular enterprise or product (Lee & Hammer, 2011). Since gamification earned popularity in the early 2010s, it has been the subject of attention from educational researchers (Swacha, 2021). The use of gamification in the learning process of college students in the Republic of Kazakhstan has been updated since 2019 (Uaisova & Komarov, 2019).

Kapp (2012) described gamification as “the ideal process for creating engaging learning environments”. It supports interesting and exciting teaching as it includes game elements such as points, levels, badges and leaderboards.

Gamification techniques are commonly applied by the field of education to enhance the motivation and involvement of students in educational activities (Alomari, Al-Samarraie, & Yousef, 2019). Although it is well known that gamification facilitates a more engaging learning framework, the evidence regarding its impact on students’ performance in courses is not as firm. In addition, most studies emphasize general mathematics performance, as opposed to algebra and the fundamentals of analysis, which are examples of cognitively demanding fields. Furthermore, there is a lack of quantitative studies in real classroom contexts that compare gamified teaching instruction to traditional teaching methods with measurable learning outcomes. According to Huang et al. (2018), when players can choose the level, and levels are markers of their sense of autonomy and competence, they may be more motivated to perform. Other gamification components, namely rewards, assignments, feedback, and avatars, were also introduced independently or in conjunction with other gamification methods (Alomari et al., 2019).

Gamification methods are widely used in education to enhance the motivation of students and their involvement in various educational activities (Alomari, Al-Samarraie, & Yousef, 2019). Although it is well known that gamification facilitates a more engaging learning framework, the evidence regarding its impact on students’ performance in courses is not as firm. In addition, most studies emphasize general mathematics performance, as opposed to algebra and the fundamentals of analysis, which are examples of cognitively demanding fields. Moreover, many existing studies focus on general mathematics performance rather than on algebra and the fundamentals of analysis as distinct and cognitively demanding domains. In addition, there is a lack of quantitative studies conducted in authentic classroom settings that directly compare gamified instruction with traditional teaching approaches using measurable learning outcomes. According to Huang et al. (2018), players may be

more motivated while having the privilege to select the level, and levels refer to their sense of autonomy and competence. Other gamification elements, such as rewards, assignments, feedback, and avatars, have also been implemented either independently or in combination with other gamification strategies (Alomari et al., 2019).

Problem statement: While international frameworks heavily emphasize student autonomy, the domestic reality in secondary mathematics education within Kazakhstan frequently mirrors more traditional, teacher-centric paradigms. Researchers note that upper-secondary instruction often prioritizes rigid procedural practice and rote lecturing over active student engagement (Baymyrzayev et al., 2023). This persistent reliance on passive learning models has created an urgent need to modernize the local instructional ecosystem, particularly through interactive frameworks that address underlying motivational deficits among senior graders (Uaisova & Komarov, 2019). Although gamification has shown promising results in increasing students' motivation and engagement, several important gaps still remain in the research literature. Most existing studies have been conducted in primary or lower-secondary school settings and mainly focus on topics such as arithmetic, basic algebra, and number sense (Hamari et al., 2014; Subhash & Cudney, 2018). In contrast, there are relatively few studies examining the effects of gamification in upper-secondary mathematics, especially in more advanced topics taught in Grade 10 and above, such as algebraic and analytical concepts.

This gap is important for several reasons. First, upper-secondary mathematics differs significantly from mathematics taught in earlier grades. Students are expected to move beyond procedural calculations and begin working with more abstract mathematical ideas, which many learners find challenging (Tall, 2013). Because of this shift, teaching strategies that are effective in primary school may not automatically work in more advanced mathematics classrooms. Second, tenth grade students are at an important stage of personal and academic development. Their motivation, confidence, peer relationships, and attitudes toward learning can strongly influence how they experience mathematics in the classroom (Eccles & Wigfield,

2002). As a result, gamification strategies should be designed carefully with these developmental characteristics in mind.

This issue becomes even more significant due to ongoing educational reforms in Kazakhstan. In recent decades, the national curriculum has increasingly emphasized critical thinking, problem-solving, and student-centered learning approaches, particularly after the introduction of the updated curriculum standards. However, despite these reforms, mathematics instruction in upper-secondary schools often remains focused on teacher explanations and procedural practice rather than active student engagement (Baymyrzayev et al., 2023; Oteniyazov, 2023). This creates a need for well-designed and carefully evaluated instructional approaches that can support the goals of the reform and improve students' learning experiences.

In addition, if a study only measures achievement, it may show whether students improved, but it does not show whether students actually experienced the intervention as gameful. Therefore, the main problem addressed in this study is that the limited evidence on whether gamified learning strategies can improve Grade 10 students' achievement in Algebra and the Fundamentals of Analysis compared with traditional instruction, and how students perceive the gamified learning experience after the intervention. Without research conducted specifically within the context of upper-secondary mathematics education in Kazakhstan, teachers and educational policymakers have limited evidence for deciding whether and how gamification should be implemented in mathematics classrooms.

Research Questions:

RQ1. To what extent do gamified learning strategies affect Grade 10 students' achievement in Algebra and the Fundamentals of Analysis compared with traditional instruction?

RQ2. How do students in the experimental group perceive the gamified learning experience after the intervention?

Research Objectives:

1. To measure changes in students' academic achievement in algebra and the fundamentals of analysis following the implementation of gamified learning strategies.
2. To compare the achievement outcomes of students receiving gamified instruction with those receiving traditional instruction.
3. To measure students' perceptions of the gamified learning experience after the intervention using the questionnaire.

Aim of the Study: To investigate the impact of gamified learning strategies on Grade 10 students' achievement in Algebra and the Fundamentals of Analysis compared with traditional instruction. The study also seeks to analyse the students' perceptions of the gamified learning experience after intervention in the experimental group. More specifically, the components of students' perceptions of accomplishment, challenge, competition, guidance, immersion, playfulness, and social experience will be examined.

The main hypothesis of this study is that the implementation of gamified learning strategies will significantly improve students' achievement in Algebra and the Fundamentals of Analysis compared with traditional instruction, while also creating a positive learning experience for students in the experimental group.

Purpose of the Study: The primary purpose of this study is to evaluate the effectiveness of gamified learning strategies in improving student achievement in Grade 10 Algebra and the Fundamentals of Analysis compared with traditional instruction. In addition to measuring academic achievement, this study also aims to understand how students experience gamified learning after the intervention. For this reason, students in the experimental group will complete the Gameful Experience Questionnaire (GAMEFULQUEST), which helps identify whether they perceived the lessons as engaging, guided, playful, challenging, social, and motivating. By analyzing the results, this research seeks to determine whether gamification

techniques can serve as a valuable instructional tool for mathematics teachers in Kazakhstan.

In this paper, knowledge is treated as measurable, which places this work primarily within a quantitative research tradition, supported by quasi-experimental logic. The main goal is asking whether observable changes occur in achievement scores when gamified strategies are used. This aligns with an objectivist epistemological stance and a post-positivist ontological position.

Overall, this study explores the impact of gamification techniques on algebra learning, with an emphasis on student achievement and student perceptions of gamified instruction. Using a quantitative research approach, the study will collect achievement data through pre- and post-intervention assessments in order to examine changes in students' academic performance. In addition, the GAMEFULQUEST will be used to investigate how students in the experimental group perceive the gamified learning experience. The study is expected to contribute to the development of mathematics education by examining the role of gamification whether it can be used as a practical teaching approach in upper-secondary mathematics classrooms.

2. LITERATURE REVIEW

As Hersch (1997) argued, mathematics is a “a social-cultural-historic phenomenon, that has reality or existence only as part of human culture, historically evolved, and intelligible only in a social context” (Dooley et al., 2014).

Mathematics is not only the science of numbers and shapes, it is more than that: as a subject, it studies structure, quantity, relationships, and various topics related to patterns, shapes, change and space. It contributes to the training of the mind and is regarded as an indispensable discipline.

Due to the importance of mathematics, it can be seen that in today’s world there is an increasing emphasis on effective mathematics teaching at all levels of education. Before the COVID-19 pandemic, math and science engagement among students was a challenge for teachers (Nieto-Escamez & Roldán-Tapia, 2021). Especially after the pandemic with the emergence of virtual learning in education, competition became even greater along with unexpected challenges (Dhawan, 2020). Even so it is easy to see that more and more of today’s students do not show much interest in mathematics. For instance, the Trends in International Mathematics and Science Study (TIMSS) 2019 assessed the mathematics and science achievement of fourth- and eighth-grade students across 64 countries and 8 benchmarking systems, continuing an international assessment program that has been conducted since 1995 (Mullis et al., 2020). From that time, it provides trends in science achievement, and mathematics. At the eighth grade, according to the percentage of students who reported they like to learn mathematics of which only 26% of Kazakhstani students liked math “very much” but despite this their average achievement was 509 scale score points while the average achievement among all countries is 500. So, this shows that even though the majority of students (54%) responded “somewhat”, their average achievement is not too different from those who like learning mathematics “very much”. The difference between them is only 25 scale score points.

2.1 Mathematics Education and Student Engagement

Algebra is often the branch of mathematics where students have to think in a new, abstract way, which is challenging for many of them. A foundation for advanced studies in STEM (Science, Technology, Engineering and Mathematics) is algebra. One of the key goals of high school algebra is to learn how to solve various equations, during which formal-operational and computational skills are developed. A lot of mathematics experts also consider algebraic skills and knowledge essential for higher education success besides for producing a qualified employee for scientific and technical careers (Star, et al., 2015). However, learning algebra is often perceived as challenging and abstract, which can alienate students and reduce their motivation to engage with learning outcomes.

Learning has an effect on people's attitudes, actions and decisions as a process that people pass through to acquire new skills and information. During the learning process, activities are carried out to achieve educational goals. These activities can be undertaken individually, but they occur within a cultural and social context where individuals integrate new knowledge with their existing cognitive frameworks.

Learning entails more than just attending a class. Remembering and application of new information and skills will range from 10% to 30% while taking a class depending on the type of topic and class. Learning, delineated as the iterative process through which individuals assimilate novel information and skills, consequently shaping their attitudes, decisions, and behavioural repertoire, embodies a multifaceted journey toward educational attainment.

All students learn something new in their own way. Some cannot maintain focus on a specific task for a long period of time, and others take in information differently. No matter how different they are, students are supposed to learn the same things and master them during a lesson. Teaching and helping all students are difficult and require differentiated instruction. According to Willoughby (2005), “differentiated instruction is a method in which teachers construct learning

environments to accommodate the different learning styles, abilities, and interests in the classroom”.

At the moment the actual problem of modern pedagogy is the search for teaching methods and means, forms that contribute to the formation and maintenance of motivation in the classroom, namely positive intrinsic motivation. Kazakhstan is now operating under the traditional educational model. The conventional educational intervention was primarily dependent on the instructor presenting the material in an explanatory manner and without the use of technological means to accomplish this. Essentially, the teacher’s function evolved into one of imparting content as the only source of information, with activities being carried out on the traditional chalkboard and chalk.

Specifically, it is usually noticed that students have no interest in math, this is mainly due to the fact that most math instructions focus on memorizing facts, practice, rote learning (Lesser, 2000). The students’ involvement had been reduced to little more than simply listening to the teacher’s demonstrations; as a result, there had been exchanges with the topic, but there had been virtually no interactions with their peers or with the teacher. After the lecturer has discussed the topics that will be covered in each session, the scholars do independent projects in class in their notebooks to put what they have learned into practice.

For the reason that the student’s activity and orientation to the cognitive process determine the effectiveness of learning, the child should be motivated not only by the result, but also by the process of learning activity. Dooley et al., (2014) argued that by using one of the newest methods in education - gamification (game technologies) to increase progress in student learning and motivation, mathematics can be perceived as a valuable perspective for representing and shaping the world.

2.2 Overview of Gamification

2.2.1 Definition and Concept of Gamification

Before discussing the definition of gamification, the context of the game should be identified. It is a fact that many individuals, including both children and grown-ups, spend plenty of time playing games on gadgets (Griffiths, 2002). Kids are attracted to participating in video games because of the opportunity to immerse themselves in a virtual environment, which is fraught with serious difficulties and passion, which ultimately allows them to master a new interactive form of communication (Levasseur, 2011).

The game is a system with abstract tasks defined by rules, interactivity and feedback. The result of the game is a quantitative result, which often causes an emotional reaction in people (Koster, 2013). For example, M. Zhumabayev's said about games: "A child's imagination is revealed especially in your mind", "A game is a life experience for a child" (Kadirbayeva, Sansyzbayev, & Saduakadova, 2023). In educational games, teachers can merge fun elements with educational concepts to boost students' motivation and engagement (Al-Azawi et al., 2016). According to Zainuddin et al. (2020), badges, avatars, levels, points, social graphs, quests are examples of game elements.

Kapp (2012) defined them as:

System: The system consists of a collection of interrelated elements that exist in the "game space". The number of points is related to the strategy or movement of the pieces and corresponds to the behaviour and actions. The essence of the system is that each component of the game affects other components of the game and is interconnected with them. The results depend on the actions, and these actions are limited by the rules.

Players: Games entail an individual engaging with game content or with fellow players. The individual participating in the game is referred to as the player. Engaging in gameplay often leads to acquiring new knowledge, and learners are the intended audience for incorporating game elements into instructional practices.

Abstract: Games, as a rule, are an imitation of reality and usually unfold in a certain “game space”. This implies that a game includes aspects of a real scenario or its essence but is not an exact replica.

Challenge: Games present players with difficult challenges in achieving goals and results that are not simple or straightforward. Even such a simple game presents a difficult challenge when you face an opponent who is equally well versed in the game. The game loses its appeal when the difficulty decreases.

Rules: The regulations of the game establish its framework. They serve as the foundation that enables artificial creation to function. These rules outline the order of gameplay, the conditions for winning, and what is considered “fair” or “unfair” within the game environment.

Feedback: Feedback is an important aspect of games. Feedback in games is usually instant, clear and unambiguous. Players can take feedback and make adjustments or changes based on both positive and negative feedback.

Quantifiable Outcome: The games are structured in such a way that the winner is clearly defined. There is no uncertainty here. Regardless of whether it is about the score, the level, or the winning condition, there is a certain result. This property makes games suitable for educational environments.

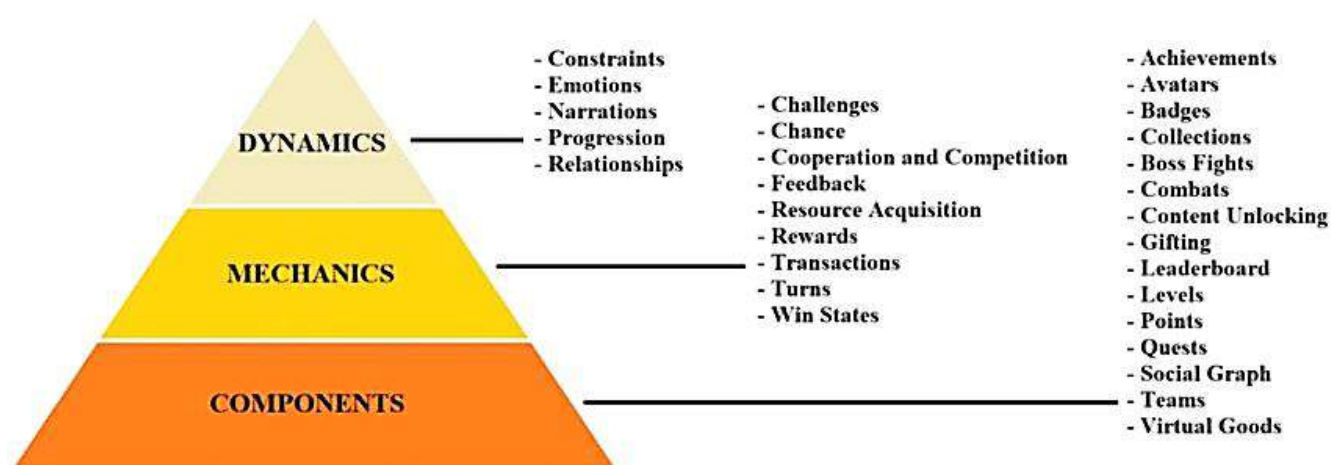
The term “gamification” has been explained in many studies. According to Deterding et al. (2011), gamification is the “use of game mechanics in non-gaming context”.

Gamification is also used as a strategy to promote products and services by offering badges, discounts, and rewards for visiting shops or using mobile apps to check in (Lee & Hammer, 2011). Over the past decade, gaming has advanced significantly and has increasingly been used as an educational tool across different fields of study (Karagiorgas & Niemann, 2017). Kapp (2012) calls attention to the practicing of “game-based mechanics, aesthetics, and game-thinking to engage people, motivate action, promote learning, and problem solving”.

Due to personal data tracking, cheaper technologies, the movement in the field of game research, and also the general prevalence of video games as a media, this concept has been carried over and adjusted to various contexts such as the workplace, education in general, and healthcare (Seaborn & Fels, 2015). There are also many other mechanisms obtainable in gamified systems, such as content unlocking, battles, gifts, quests, boss fights, social media, and certificates (Buckley & Doyle, 2017).

To create a gamified system correctly, the focus should be on the following aspects. Karamert and Kuyumcu Vardar (2021) argued that using game elements can improve students' maths performance and make them more motivated if they prioritise and organise game elements correctly. Werbach and Hunter (2012) developed a design model for integrating gamification. In Figure 2.2.1.1, elements of this model are demonstrated.

Figure 2.2.1.1. Pyramidal design model



2.2.2 History of gamification

The historical cornerstone of gamification was laid in 1973 in connection with the decline in workplace productivity. The intention of gamification was to eradicate the absence of involvement, adaptation and employee retention, which led designers and researchers to gamification in the branch of education (Coonradt & Nelson, 2012). Companies utilise gamified tools like leaderboard, rewards, acknowledgments, indicators of progress, and competitions to inspire and involve their staff (Kim & Werbach, 2016). Coonradt and Nelson (2012) provided examples of how employees

use accurate performance accounting to compare their work with past results, evaluate it according to an established standard, and admit regular, immediate, and meaningful feedback. 87% of American employees documented that the introduction of this approach into the professional environment led to an increase in staff efficiency, while 80% of employees noted that learning with gamification elements is a great pleasure. Gamification has been associated with a 60% increase in workplace engagement and a 50% rise in productivity (Wingo et al., 2019). It has also been applied in military settings, where badges and ranks have long been used as recognition systems. During the early Soviet period, game-like elements were used by Soviet leaders as an alternative to monetary rewards for workplace achievements (Richard et al., 2018).

The individual with foresight who observed this occurrence and coined the term gamification in the year 2002 was Nick Pelling, a computer game developer. Pelling described it as the incorporation of game elements into the field of education (Marczewski, 2013). According to Pelling (2011), term gamification means “the usage of hastened game-like user interface design in order to make electronic transactions delightful and quick”. Despite his initial aim to introduce entertaining features into transactions such as ATM withdrawals and enhance the lacklustre in-flight entertainment system, this idea did not appeal to technical users (Sanmugam, 2015). In 2007, Rajat Paharia established Bunchball as the pioneering gamification platform that applied gaming elements to the corporate world. Bunchball provided a gamification solution enabling companies to develop, evaluate, and execute gamified systems for employees and teams, accessible on desktops or mobile devices worldwide, including New York State (Kim & Werbach, 2016). The game mechanics were put into practice, and a number of many terms were introduced, such as performance enhancing games, behavioral games, entertainment software, game design, game level, exploitation software, animation and gamification (Shen, 2020).

2.2.3 Gamification and Game-Based Learning

Gamification is closely related to game-based learning, serious games, and other game-based educational approaches, as these concepts all use game-related

principles to support learning. However, they are not identical. Game-based learning refers to the use of games or game-like activities to achieve specific educational objectives, often by engaging learners in problem-solving tasks and challenges (Qian & Clark, 2016). Gamification, by contrast, involves incorporating selected game-design elements into non-game educational contexts rather than using a complete game as the main learning environment (Deterding et al., 2011; Perrotta et al., 2013). In gamified learning environments, elements such as levels, feedback, goals, and progression can be used to structure learning activities and support students' engagement with educational content (Krath et al., 2021). Scholars typically distinguish between learning outcomes, behavioural outcomes, and either effective, when investigating the outcomes of gamification and game-based learning (Carenys & Moya, 2016). Game Based Learning is consumed to motivate students to engage in learning through play, enhancing the learning process by infusing fun into it. The example of a game-based learning classroom is the application of Kahoot for creating an interactive and immersive learning setting that attracts the attention of students and promotes active participation (Correia & Santos, 2017).

Traditional teacher-centered instruction may not be enough for teaching in the modern mathematics classroom towards active engagement, creativity and problem solving. For instance, it is not uncommon for children to have less opportunity to think out of the box, as well as to do hands-on tasks that require hands-on experience under more explanation, repetition and routine exercises (Al-Azawi et al., 2016). Many adolescents have also been influenced by a growing background in a computerized world where they encounter computers, smartphones and online applications that frequently link them to computer, mobile, online systems or game technology. Consequently, pure traditional classroom environments that revolve around teacher discussion and chalkboard instruction may be found to be less engaging for certain students (Sanmugam et al., 2015).

Gamification is not the same as full game-based learning in that it may also not entail the use of full games. Instead it adopts some game-specific elements of a game

such as points, levels, feedback, goals, and progression into non-game educational contexts (Deterding et al., 2011; Krath et al., 2021). These elements can help create learning activities, help motivate users, and contribute to more engaging learning moments. The literature provides support for the assertion that gamification can be a promising tool for learning and engagement in the classroom when it is well integrated into educational goals and is closely related to student participation and academic achievement (Kapp, 2012; Zainuddin et al., 2020).

The term gamification is used in settings outside the game. Specifically, gamification allows to apply the game to an environment where the principles of the are not applied (Deterding et al., 2011).

2.3 Theoretical Foundations of Gamification in Education

It is necessary to examine the psychological and pedagogical theories that explain learning, motivation, and engagement to fully understand how gamification may influence students' achievement. This study is grounded in three theoretical frameworks: Self-Determination Theory, Flow Theory, and Vygotsky's Zone of Proximal Development. Together, these theories provide a rationale for using game-design elements in the teaching of Algebra and the Fundamentals of Analysis, as they explain how challenge, feedback, progression, autonomy, and social interaction can support students' active participation and academic growth.

2.3.1 Self-Determination Theory

In the context of gamified mathematics instruction, Self-Determination Theory (SDT) provides an important explanation of how game-design elements may support students' motivation and achievement. Developed by Deci and Ryan (1985, 2000), SDT suggests that learners become more motivated when three basic psychological needs are met: autonomy, competence, and relatedness. Autonomy means the feeling of having volition - the feeling that you are acting from your own will and not being pushed into anything by others. Competence is the feeling that one must feel effective and proficient; competence is the perceived ability to interact effectively with or on

behalf of an individual (or community) within the environment. Relatedness is the need for meaningful social connection to others (Ryan & Deci, 2017).

In mathematics education, SDT has been applied numerous times, with consistent evidence from studies demonstrating that when classroom environments facilitate autonomy and competence (through choice, meaningful challenge, and informational feedback), students report greater intrinsic motivation and deeper conceptual engagement (Vansteenkiste et al., 2006; Corpus et al., 2009). Gamification is closely connected to the principles of Self-Determination Theory as it can create learning conditions that support autonomy, competence, and relatedness. Quest structures and branching paths support autonomy by giving students agency in the sequence and pace of tasks; levelled challenge systems and immediate corrective feedback scaffold competence by ensuring that tasks are not trivially easy nor unattainably difficult; and cooperative team challenges address relatedness when they create meaningful social contexts for mathematical work (Mekler et al., 2017).

A key distinction within SDT is between autonomous and controlled motivation. Autonomous motivation - doing something because it is intrinsically interesting or relevant to you - is related to deeper learning, increased persistence, and greater attainment. Controlled motivation - doing something to receive external rewards or escape punishment - is linked to shallow processing and reduced long-term retention (Deci et al., 1999). This distinction has significant implications for the designing of gamification systems, because systems that heavily involve extrinsic rewards (such as points and leaderboards) can effectively move students' motivational orientation from autonomous to controlled, potentially detracting from the kind of engagement that the system aims to foster. Well-conceived gamification uses those parts of games primarily as informational feedback (as a means of conveying progress and mastery) rather than as external incentives that substitute for genuine mathematical interest.

2.3.2 Flow Theory

The ability to maintain flow, as described by Csikszentmihalyi (1990), describes a state of mind full of the essence of effortless involvement and intrinsic reward that

one will experience if the player's skill level coincides with the level of challenge presented by an activity. Flow Theory is particularly relevant to gamified instruction because well-designed game elements can help maintain an appropriate balance between challenge and students' abilities. During a flow state, learners become fully engaged in an activity, lose awareness of time, and experience the learning process as meaningful and rewarding. Csikszentmihalyi (1990) argues that flow is most likely to occur when goals are clear, feedback is immediate, and the level of challenge matches the learner's skill level. This is especially important because students usually enter the classroom with different levels of preparation in Algebra and the Fundamentals of Analysis. If all students receive the same level of tasks, some may feel bored because the work is too simple, while others may feel anxious because the content is too difficult. Gamified learning can address this issue by organizing mathematical tasks into levels, challenges, and progressive stages that allow students to work at a suitable level of difficulty while still being encouraged to improve. Gamification overcomes this barrier as it generates adaptive and levelled task structures in which the level of complexity matches the level of a student currently working at - what Vygotsky (1978) referred to as the zone of proximal development - with these constructs facilitating conditions for flow (Hamari et al., 2016). This is the type of immediate feedback that is characteristic of well-designed gamification systems, facilitating flow by delivering the clear information signal which Csikszentmihalyi perceives as fundamental to maintaining optimal engagement.

2.3.3 Vygotsky's zone of proximal development (ZPD)

Vygotsky's (1978) concept of the zone of proximal development (ZPD) examines the cognitive distance between what a learner can accomplish independently and what must be learned with the assistance of a more knowledgeable person such as a teacher, peer, or within an organized system. According to him, learning occurs best within this zone: tasks far beyond the ZPD do not lead to learning because they have already been mastered, while tasks entirely beyond it lead to frustration and failure.

Gamification does a number of things to bring the ZPD to reality. Levelled challenge systems provide students with tasks which are just beyond their current ability to function independently (due to this, the task is a “check-up,” with the challenge levels in place at all times). Hint and scaffold systems - prevalent in digital gamification environments - give students just-in-time assistance to finish tasks they couldn't do alone, modeling expert thinking patterns and then slowly removing support when mastery is achieved. Collaborative team challenges utilise peer mediation in the ZPD: when higher-level students share their reasoning with slightly behind-the-tier peers, both sides are able to gain - the explainer by consolidation and reorganisation of their own thinking, the listener by being exposed to thought processes situated within the ZPD (Vygotsky, 1978; Wood et al., 1976).

2.4 Gamification and Student Motivation

The empirical literature reveals a nuanced consensus regarding gamification's efficacy. While systematic reviews by Hamari et al. (2014) and Dicheva et al. (2015) underscore a generally positive trajectory for student motivation and engagement, this success remains highly contingent on design fidelity. Indeed, when game mechanics rely excessively on forced extrinsic rewards, they can actively depress learner motivation and satisfaction, as demonstrated in the longitudinal findings of Hanus and Fox (2015).

More recent studies also confirmed and nuanced these findings. According to Subhash and Cudney (2018), 41 studies have been reviewed and concluded that gamification was associated with increased student motivation, participation, and satisfaction in both secondary and tertiary education environments. Crucially, they discovered other moderating factors: gamification was most effective for motivation if students believed it was fair; if it contained collaborative (rather than purely competitive) components; and if introduced as a pedagogical approach, not as a superficial add-on. These results echo the SDT prediction that gamification components increase motivation when they enhance, rather than hinder, autonomous engagement.

With respect to mathematics anxiety - a particularly relevant construct in the Algebra and Fundamentals of Analysis curriculum - research suggests that gamification can mitigate negative affect toward mathematics. Ashcraft and Moore (2009) found that mathematics anxiety impairs working memory and procedural performance in a vicious cycle where anxiety leads to avoidance that leads to underperformance that leads to more anxiety. Gamification, on the other hand, may help break this cycle by reframing mathematical tasks as challenges in a low-stakes play environment, thereby dampening a threat response engendered in high-stakes testing (Mayer, 2019). Baymyrzayev et al. (2023), from the perspective of Kazakhstan, argue that this motivational deficit in mathematics classrooms found in many post-Soviet educational systems must be fixed by increasing the students' interest in learning utilizing inventive pedagogical approaches (e.g., gamification) which they consider as necessary strategies.

2.5 Gamification and Academic Achievement

Although the motivating effects of gamification are relatively well documented, the evidence regarding its effect on academic achievement is mixed. Results from many studies have shown favorable impacts of gamification on objective learning outcomes. Attard and Holmes (2020) used a semester-long gamified algebra unit with secondary students and observed statistically significant improvement in procedural fluency and conceptual understanding compared to matched controls. Importantly, the achievement gains were largest for students with previously low mathematics self-concept, indicating that gamification may uniquely benefit the students most likely to be disengaged and underperform.

In the context of higher education mathematics, Kyewski and Krämer (2018) did a structured design experiment to see how badge-based gamifying of achievement in an undergraduate statistics course helped the subjects perform. The students in the gamified condition who were actively involved in the badge system, especially those trying to gain optional achievement badges not part of a specified curriculum, scored much higher on tests compared to those who had not been exposed to the badges. So,

it is possible that the achievement effect of gamification is also mediated by the active involvement the gamification system involves, as opposed to being the direct effect of the gamification system's mechanics.

Not all studies are encouraging. Numerous studies have found null or mixed results on achievement. Hanus and Fox (2015) conducted a semester-long study among university students where those participating in a gamified course had worse motivation, lower satisfaction level, and lower achievement than those in a conventional course. The authors explain these effects on motivation by reference to the competitive presentation of gamification, which could have generated social comparison pressure and decreased intrinsic motivation. And this discovery highlights the importance of design fidelity: badly designed gamification, especially if it depends on competitive leaderboards and rewards from outside sources, might hurt rather than improve learner performance.

In summary, the data indicates that the effect of gamification in education has a significant quality-dependent link to design quality, fidelity of implementation, as well as the educational context characteristics. Points and badges added in simple ways to existing curricula are unlikely to yield measurable achievement gains. What is needed is an informed theoretically based, principled design that matches gamification mechanics to discrete learning objectives and considers motivating forces (Mayer, 2019; Werbach & Hunter, 2012).

2.6 Gamification in Mathematics Education

While the study of gamification in mathematics education has grown in quantity over the past 10 years, the area of research has still been largely concentrated in primary and lower-secondary contexts.

The potential of digital tools in gamified mathematics learning is also noteworthy. Interactive, gamification-supportive media platforms (e.g., GeoGebra, Desmos) have been employed to organise interactive, game-like learning contexts where students are introduced to properties of functions, derivative operation, and integral applications by means of dynamic visualization (Tall, 2013). It is based on

Oteniyazov (2023)'s view that interactive methods of teaching based on digital tools could dramatically increase students' engagement in mathematics learning and is particularly conducive under the national educational modernisation drive of Kazakhstan that explicitly insists on involving in the classroom the use of digital technologies.

2.7 Cognitive Demands of Upper-Secondary Mathematics

The learning content for Algebra and Fundamentals of Analysis is marked as a substantial cognitive advance from mathematics in previous levels. The transition to formal mathematics includes the limit concept and the focus on continuity, differentiability and integrability, a task Tall (2013) describes as one of the most arduous cognitive transitions of all mathematics education; Additionally, he notes that this transition will be the hardest of all. This transition demands that students leave Tall's "embodied" and "symbolic" worlds of mathematics where understanding is based on physical intuitive processing of a particular problem or procedure; for the "formal" worlds in which definitions and theorems are abstract logical entities to be understood and manipulated independently of their relevance to physical intuition.

The concept of the derivative is arguably the biggest and hardest conceptual element of the analysis component of the Grade 10-11 curriculum for students at this level. Research has repeatedly shown that students can correctly master differentiation rules procedurally yet have no comprehension of what the derivative stands for (Zandieh, 2000). There are similar struggles when dealing with the integral, where students tend to treat integration as "reverse differentiation" without a firm understanding of the accumulation concept at the heart of the definite integral. Compounding these problems are the cumulative nature of the algebra and analysis curriculum: failure to comprehend functions, limits, or differentiation lead to learning gaps that worsen upon further learning in subsequent units.

2.8 Students' Attitude and Affect in Mathematics.

Affective factors - motivation, self-efficacy, mathematics anxiety, attitude toward the subject - are key contributors to student achievement in mathematics (Hannula, 2002). Bandura (1997) introduces the notion of self-efficacy, which is defined as believing one can perform a task and is important at the upper grades because the extent of abstraction of mathematical content leads to doubt on the competence of students. Students experiencing diminished mathematics self-efficacy are known to avoid challenging tasks, quickly lose interest when confronted with difficulty, and practice surface level strategies such as memorisation, and algorithmic imitation (Eccles & Wigfield, 2002).

Mathematics anxiety, the negative affect and tension that mathematics performance has to produce, is well-studied and directly related to working memory and procedural performance (Ashcraft & Moore, 2009). In the Algebra and Fundamentals of Analysis course, where procedural fluency in symbolic manipulation needs to be balanced with conceptual understanding of abstract ideas, anxiety-impaired working memory combined with conceptual confusion could lead to a particularly severe performance deficit. OECD (2023) data highlight that math anxiety is much more common in Central Asian and Eastern European educational systems compared to OECD-average countries with respect to Kazakhstani contexts.

2.9 Student Achievement and Engagement in Kazakhstani Mathematics Education

Numerous pedagogical methods have been examined for their effectiveness in addressing the motivational and cognitive demands of upper-secondary mathematics. Problem-based learning (PBL), which structures instruction around real-world or open-ended tasks to foster greater engagement, has been associated with enhanced conceptual understanding and improved mathematical communication. However, successful implementation of PBL requires specialized pedagogical expertise (Hmelo-Silver, 2004). Cooperative learning approaches, such as group projects involving

structured tasks in small groups, have consistently resulted in higher levels of conceptual content performance compared to independent work, particularly for tasks emphasizing logic and explanation (Johnson & Johnson, 2009).

Technological-supported instruction, notably through dynamic geometry and computer algebra systems, is associated with the growth of the visual and conceptual imagery that undergirds the comprehension of functions, derivatives, and integrals (Tall, 2013). But technology alone cannot be enough: research has consistently shown that the pedagogical design of technological tools is much more important than the tools themselves in determining learning outcomes (Heid & Blume, 2008). Gamification can therefore provide a pedagogical design layer which can be infused into, and potentially enhance, each of these approaches by providing motivational scaffolding as well as narrative coherence on otherwise disparate instructional activities.

Kazakhstan's educational system has undergone considerable change over the past two decades as part of a broader national modernisation agenda. The introduction of the revised curriculum standards in 2016 marked a significant shift in educational thinking. It also moved from mainly content transmission modes to an outcome-based approach that highlights critical thinking skills, the competences needed for problem-solving and child-centred teaching. The mathematics curriculum, which includes the course Algebra and Fundamentals of Analysis for Grades 10-11, was changed to reflect these priorities. The focus was upon mathematical modeling, applied problem-solving, and cross-disciplinary connections.

There is a high policy priority given to learner-centred pedagogy, a gap may still exist between the goals of educational reform and everyday classroom practice. In many mathematics classrooms, instruction may remain strongly influenced by teacher explanation, procedural practice, and preparation for high-stakes assessment. This creates a need for pedagogical approaches that can support more active student participation, collaboration, feedback, and engagement in mathematics learning. In this context, gamification may offer a practical way to structure learning activities while

maintaining alignment with curriculum objectives (Baymyrzayev et al., 2023; OECD, 2023; Uaisova & Komarov, 2019).

The performance of Kazakhstani students in international measures of mathematics achievement presents a complex narrative. Although there has been an upward trend in performance on Program for International Student Assessment (PISA) mathematics across successive cycles, scores remain significantly below the Organisation for Economic Co-operation and Development (OECD) benchmark. Furthermore, variation within the country is substantial, characterized by pronounced achievement disparities between rural and urban schools, as well as across differing socioeconomic groups (OECD, 2023). Student self-reports from the 2022 PISA cycle indicate low mathematics confidence and elevated mathematics anxiety, with numerous students reporting feelings of helplessness when confronted with mathematical problems (OECD, 2023). These findings underscore both motivational and achievement challenges in upper-secondary mathematics within Kazakhstan. The discrepancy between the aspirational goals of educational reform and the realities of student disengagement and underperformance emphasizes the need for evidence-based, implementation-ready pedagogical interventions. Gamification, due to its theoretical alignment with established motivational frameworks and relatively modest resource requirements, emerges as a promising candidate for rigorous empirical investigation in this educational context (Baimyrzayev et al., 2023; Uaisova & Komarov, 2019).

Student self-reports on the 2022 PISA assessment reflect low mathematics confidence and a high mathematics anxiety; several students described feeling helpless when facing mathematical problems. On the one hand, these findings suggest motivational and achievement problem in Kazakhstani upper-secondary mathematics. This mismatch between aspirational vision for educational reform and the realities of disengagement and underperforming students highlights the importance of evidence-based, implementation-ready pedagogical initiatives. Gamification, given its theoretical alignment with established motivational frameworks and its relatively

modest resource requirements, presents itself as a candidate worthy of rigorous empirical investigation in this specific educational context (Uaisova & Komarov, 2019; Baimyrzayev et al., 2023).

2.10 Potential and Challenges of Gamification in Kazakhstani Classrooms

Gamification has been getting more and more attention internationally, and relatively few studies have empirically applied this in high school mathematics of Kazakhstan. Recent studies indicate that gamified educational tools may be incorporated into secondary mathematics teaching as a way to increase student attention and academic achievement (Sansyzbayev et al., 2025). But effective integration does not operate solely by gamified tools but it also relies on the readiness of teachers to design these tools into classroom contexts and curriculum requirements. In a qualitative study, conducted by Seilbayeva in Bilim-Innovation high schools in Kazakhstan, it was found that most of the teachers acknowledged the motivational effect of gamification, although it was still new in the context of Kazakhstan, being used exclusively by a select number of educational institutions and certain educators. So, gamification ought to be implemented as a pedagogically planned instructional technique, not as a further enjoyable element.

The integration of gamified learning environments within the secondary education system of Kazakhstan presents a unique intersection of progressive policy opportunities and distinct institutional obstacles. Under the national educational modernization drive, the Ministry of Education has explicitly advocated for student-centered instructional models and digital tool adoption (OECD, 2023). Gamification fits structurally within this mandate by providing dynamic, non-traditional methods to activate student engagement.

Secondary education in Kazakhstan is strongly influenced by high-stakes assessment, including the Unified National Testing, which may encourage teachers to prioritize curriculum coverage and examination-oriented preparation over more interactive classroom activities (OECD, 2020). Amirova et al. (2023) also noted that

unequal access to digital infrastructure may affect the implementation of technology-supported gamification, especially in regional or rural educational contexts. Therefore, gamified instruction in Kazakhstan should include both digital and low-tech elements, such as point systems, printed task cards, progress charts, badges, and collaborative classroom challenges (Uaisova & Komarov, 2019).

2.11 Structural Gamification Elements and Their Pedagogical Scaffolding

Rather than treating gamification as an abstract, singular phenomenon, educational designers categorize it into a series of distinct behavioral mechanics and structural elements. When applied to cognitively demanding fields like Grade 10 Algebra and the Fundamentals of Analysis, each structural component must be designed to serve specific instructional scaffolding functions rather than mere entertainment (Kapp, 2012).

Points represent the foundational baseline element of most gamified applications, acting as the primary informational ledger for student progression. From an instructional perspective, point accumulation offers immediate, unambiguous feedback regarding task performance and level of active participation (Huang & Ho, 2018). Traditional evaluation systems in secondary schools rely on delayed, summative grading structures, which often leave struggling students isolated during their problem-solving processes. In contrast, immediate point tallies reward the cognitive effort involved in intermediate analytical steps (Huang et al., 2018). When students hit a cognitive wall with highly abstract calculus operations such as calculating critical points or defining intervals of increase and decrease; the immediate addition of points for operational sub-steps transforms an otherwise frustrating bottleneck into a manageable challenge. Points serve as a psychological buffer that encourages persistent task iteration over immediate abandonment (Mekler et al., 2013).

While points measure continuous progress, badges function as discrete visual representations of competency and milestone achievement. Badges move past the generic utility of grades by visually mapping out specific conceptual breakthroughs

(Seaborn & Fels, 2015). For example, a student might earn a specialized badge specifically for mastering the "First Derivative Test" or for successfully identifying optimization solutions in real-world application tasks. This explicit labeling changes the psychological value of the credential, reinforcing a growth mindset where learning is organized around competencies rather than simple point collection (Suh et al., 2018). Rather than just a gold star, badges act as clear, visual milestones of what a student has achieved and how far they have come (Seaborn & Fels, 2015).

Leaderboards introduce a social dimension into the learning environment by visually arranging student metrics in a comparative matrix. When managed properly within a positive classroom culture, leaderboards can stimulate constructive competition, inspiring peer modeling and heightened collective investment (Aldemir et al., 2017). However, empirical findings indicate that leaderboards are highly volatile design elements. If implemented carelessly in an environment with high academic disparity, they can generate intense peer pressure, lower self-efficacy, and exacerbate mathematics anxiety among lower-performing students (Alomari et al., 2019). Consequently, in advanced mathematics classrooms, leaderboards must be structured dynamically - focusing on personal growth indicators or team-based achievements - to prevent damaging student motivation (Seaborn & Fels, 2015).

Level-based systems provide the macro-structural skeleton of a gamified unit, chunking dense curricular requirements into a series of progressive, bite-sized stepping stones (Nah et al., 2014). This systematic organization prevents the cognitive overload that typically characterizes the transition into advanced upper-secondary calculus (Tall, 2013). By organizing the curriculum into lock-step hierarchical levels - where access to a higher level requires proven mastery over foundational elements - the system ensures that no student is pushed into advanced concepts like optimization without first demonstrating operational fluency in basic differentiation rules (Filatro & Cavalcanti, 2016). This progressive leveling changes the student's perception of mathematical failure, reframing a low score not as a permanent failure, but as an incomplete level that can be re-attempted and mastered (Mekler et al., 2013).

2.12 Subjective Learner Experiences and the Psychometrics of Student Perceptions

While objective academic outputs such as post-test scores provide essential verification of an intervention's impact, they provide an incomplete picture of the psychological mechanisms at play. An instructional strategy cannot be categorized as genuinely gamified simply because structural elements were added to a lesson plan; it depends on how the target audience subjectively perceives and experiences the environment (Attard & Holmes, 2020). If students perceive game mechanics as manipulative or coercive tools designed to force performance compliance, their intrinsic interest will drop (Hanus & Fox, 2015). Conversely, if they perceive the gamified environment as a safe space for procedural experimentation, it can reduce the psychological threat of failure and lower performance anxiety (Mayer, 2019). Investigating student perceptions serves as a critical bridge to ensure that structural modifications actually generate an engaging, motivating learning climate.

2.13 Measuring the Multi-Dimensionality of Engagement: The GAMEFULQUEST Scale

To systematically assess and quantify these internal student experiences, contemporary researchers move away from vague self-reports of "fun" and utilize multidimensional psychometric instruments (Koster, 2013). Chief among these is the GAMEFULQUEST questionnaire, a tool specifically designed to map out the psychological dimensions of gameful experiences within educational and non-entertainment contexts. The instrument isolates several distinct formative components that explain how secondary students interact with instructional innovations:

- **Accomplishment:** Tracks the learner's subjective sense of growth and goal fulfillment, capturing the pride a student experiences when their operational proficiency is recognized by structural milestones (Seaborn & Fels, 2015).

- **Challenge:** Measures the perceived balance between task difficulty and user skill, monitoring whether the material successfully keeps the student in a state of flow without causing anxiety or boredom (Csikszentmihalyi, 1990).
- **Competition:** Quantifies how the student responds to peer comparisons, showing whether competitive elements drove motivation or introduced counterproductive anxiety (Alomari et al., 2019).
- **Guidance:** Evaluates how clearly the rules, objectives, and systemic boundaries were communicated, ensuring that the student feels supported throughout their learning journey (Nah et al., 2014).
- **Immersion and Playfulness:** Track the deep cognitive focus and playful nature of the intervention, assessing whether abstract tasks were embraced as engaging puzzles rather than mandatory homework assignments (Koster, 2013).
- **Social Experience:** Examines the collaborative relationships and peer dynamics that emerged during collective or team-based gamified challenges (De-Marcos et al., 2016).

By assessing these target dimensions, the GAMEFULQUEST scale allows this study to go beyond basic academic metrics and uncover the specific psychological factors that explain why and how tenth-graders navigate gamified mathematics instruction.

2.14 Summary of the Literature and Identification of Research Gaps

Reviewing the literature reveals that gamified learning strategies may facilitate mathematics learning when gamified learning is a structured instructional modality based on structured mathematics instruction as opposed to a fun, play-based activity as a separate and entertaining pastime. Prior findings as well as theoretical research suggest that game elements alone are not enough to indicate that the effectiveness of a game-like education in mathematics learning will be achieved (it is only by the gamification of education strategies related to the game elements but the way in which

these elements are related to learning objectives, cognitive processes, and classroom interaction).

To counter the passive nature of traditional mathematics classrooms, contemporary Kazakhstani scholarship has begun exploring student-centered alternatives. For instance, the implementation of flipped classroom methodologies in secondary mathematics has been shown to significantly enhance conceptual understanding and student autonomy compared to standard lecture-heavy formats (Bekbolganova, 2022). This aligns with a broader pedagogical push within the region to transition toward interactive modes of instruction that expand student involvement and move away from purely expository teaching (Oteniyazov, 2023).

Self-determination theory, flow theory, Vygotsky's zone of proximal development and situated learning theory all collectively illuminate how well-designed gamification environments, which encourage autonomy, adjust challenge to skill, scaffold peer learning, and embed content in meaningful contexts, can heighten student motivation and enable richer mathematical learning. Empirical evidence tends to support positive effects of gamification on the motivation and engagement of students, but the support for effects on academic achievement is more conditional on the design quality of the gamification process and the situation of implementation. Most empirical assessments remain divided, focusing either entirely on qualitative perceptions of engagement or solely on quantitative test output. Studies rarely combine rigorous quasi-experimental achievement evaluations with a validated, multidimensional psychometric scale (such as the GAMEFULQUEST) to confirm whether achievement gains correspond with a genuinely gameful learner experience.

The current study is based on the premise that if well conducted and appropriately constructed gamified learning strategies for Algebra and the Fundamentals of Analysis are gamified for academic achievement, as well as students learning, their level of academic achievement can be positively translated into algebraic and fundamentals of analysis since these aspects increase engagement, repeated applications of teaching practice and ongoing feedback during the learning

process. Higher secondary mathematics demands that students grapple with abstract symbolic representations, functions, inequalities, and analytical reasoning that necessitate not only conceptual understanding but procedural fluency as well. Due to these cognitive demands, students are frequently faced with challenges to maintaining interest and persistence while solving difficult mathematical problems. It therefore provides, in the context of this study's conceptual framework, the view of gamification as a pedagogical framework that potentially organizes learning in a more interactive and accessible manner.

This assumption is consistent with several theoretical perspectives. Constructivist theory of learning holds that students construct meaning through involvement and interaction with a task - rather than through passive observation and receipt of information. In this study, gamified activities support a more active approach to student participation in solving algebraic and analytical problems with structured progression and guided practice. Likewise, Vygotsky's concept of the zone of proximal development says that where learning proceeds without too much assistance it becomes more effective when learners are gradually nudged along to a point of greater understanding (and more effective at understanding). So the level-based design of gamified tasks used in this study, is consistent with this principle. There is structured mathematical activity for every increasingly more difficult item which is designed to help you achieve success under difficult conditions.

Furthermore, the framework is based on cognitive load theory where complex information is given out in smaller chunks so you can better manage it and continue to digest it as well. The abstract and symbolic nature of algebra and the fundamentals of analysis usually leave learners with a high cognitive demand. Gamified approaches as techniques to split content into sections, provide frequent feedback, and visualize progress; may help minimize cognitive overloading and assist students to concentrate better on mathematical reasoning and problem solving.

Moreover, theory of skill acquisition favours the repeated, structured practice in mathematical study. Algebraic fluency and logical thinking emerge slowly from

successive instances where mathematical processes are practiced in different contexts. The gamified approaches employed in this study, focused mainly on the use of progressive-task and levelled problem sets, are designed to encourage practice while ensuring that students stay engaged in the learning mechanism.

Drawing on these theoretical perspectives, the current study takes a deep dive into the relationship between gamified learning strategies and the academic achievement of the students in Algebra and the Fundamentals of Analysis specifically. In this framework, gamified instruction serves as the independent variable, and students' achievement scores as the dependent variable. The researchers predict that the incorporation of structured gamification features into mathematics instruction may promote positive gains in mathematics learning experiences in comparison with standard instruction methods.

This current investigation is designed to directly address these empirical voids by evaluating both the academic performance shifts and the psychometric profiles of Grade 10 students navigating functional analysis within a Kazakhstani secondary school.

Overall, the theoretical framework of this study integrates the theory and empirical literature discussed in this chapter and forms the basis for the methodological decisions that we present in the next chapter.

3. METHODOLOGY

3.1 Research Design

This study used a quantitative quasi-experimental research design to investigate the impact of gamified learning strategies on students' academic achievement and subjective learning experience in Algebra and the Fundamentals of Analysis. A quantitative approach was chosen because the main purpose of the study was to examine measurable changes in students' achievement after the implementation of gamified instruction. Since the research focused on comparing students' performance before and after the intervention, quantitative methodology was considered the most appropriate approach for answering the research questions.

More specifically, the study followed a pre-test–post-test quasi-experimental design involving an experimental group and a control group (Creswell, 2014). This design made it possible to compare students' achievement levels before and after the instructional intervention and to examine whether gamified learning strategies contributed to differences in academic performance when compared with traditional teaching methods.

A true experimental design was not possible because the research was conducted in a real school environment where classes had already been formed before the beginning of the study. Therefore, students could not be randomly assigned to groups. In mathematics education research, quasi-experimental designs are frequently used in classroom settings where maintaining natural learning conditions is important. Although this design does not provide complete control over all variables, it allows researchers to examine instructional interventions within authentic educational contexts.

3.2 Research Context and Participants

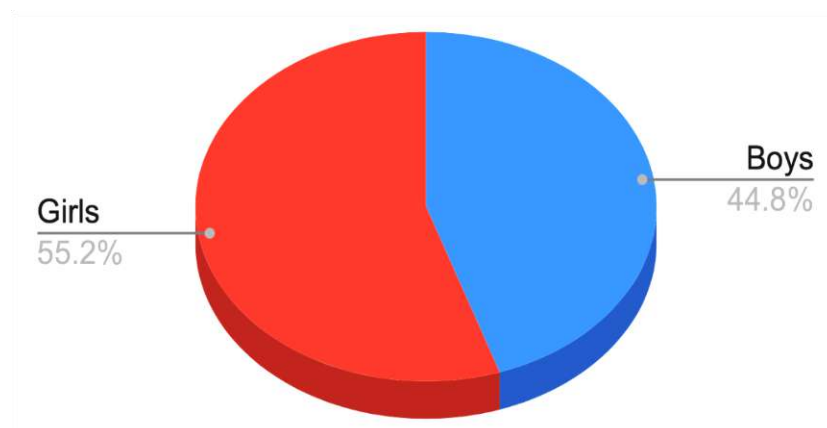
The study was conducted in one secondary school involving Grade 10 students enrolled in the subject Algebra and the Fundamentals of Analysis. Grade 10 was selected because students at this stage begin working with more abstract mathematical

concepts that require analytical reasoning, conceptual understanding, and procedural fluency.

In total, 58 students from four Grade 10 classes participated in the research. Two classes were randomly assigned to the experimental group, while the remaining two classes formed the control group. Class 10A and Class 10Γ formed the experimental group, while Class 10Θ and Class 10F formed the control group. Although the number of students in each classroom varied slightly, the total number of participants in the experimental and control conditions was equal. This distribution supported comparability between the groups during the analysis of achievement outcomes.

Figure 3.2.1 presents the gender distribution of the participants involved in the study.

Figure 3.2.1. Demographic data



As shown in the figure, the total sample consisted of 58 participants, including 26 boys and 32 girls. This means that girls represented a slightly larger proportion of the sample than boys. Specifically, girls accounted for approximately 55.2% of the participants, while boys accounted for approximately 44.8%. The experimental group had a mean pre-test score of 10.28, while the control group had a mean pre-test score of 10.52, indicating that the two groups had similar achievement levels before the intervention.

An additional contextual characteristic of the participants should also be noted. The school where the study was conducted was opened only in the current academic

year. As a result, the students participating in the research had only recently been brought together and met each other for the first time in this educational setting. Prior to entering this school, they had studied in different schools and had been taught by different mathematics teachers using potentially different instructional approaches. Consequently, students entered the study with diverse academic backgrounds, previous learning experiences, and levels of mathematical preparation. This characteristic reflects the authentic educational conditions in which the study was conducted and represents the natural diversity commonly present in newly formed classroom groups.

Both groups studied the same mathematical topics and followed the same curriculum during the intervention period. The main difference between the groups was the teaching approach used during lessons. The experimental group learned through gamified instructional strategies, while the control group continued learning through traditional teaching methods. The instructional intervention focused specifically on derivative-based investigation of functions, including critical points, extrema, intervals of increase and decrease, monotonicity, and maximum and minimum value problems. These topics were selected because they are part of the official Grade 10 curriculum for Algebra and the Fundamentals of Analysis and are expected to be covered during the academic year. In addition, these topics are considered cognitively demanding for many students due to the abstract and analytical nature of derivative-based function analysis.

3.3 Instructional Intervention

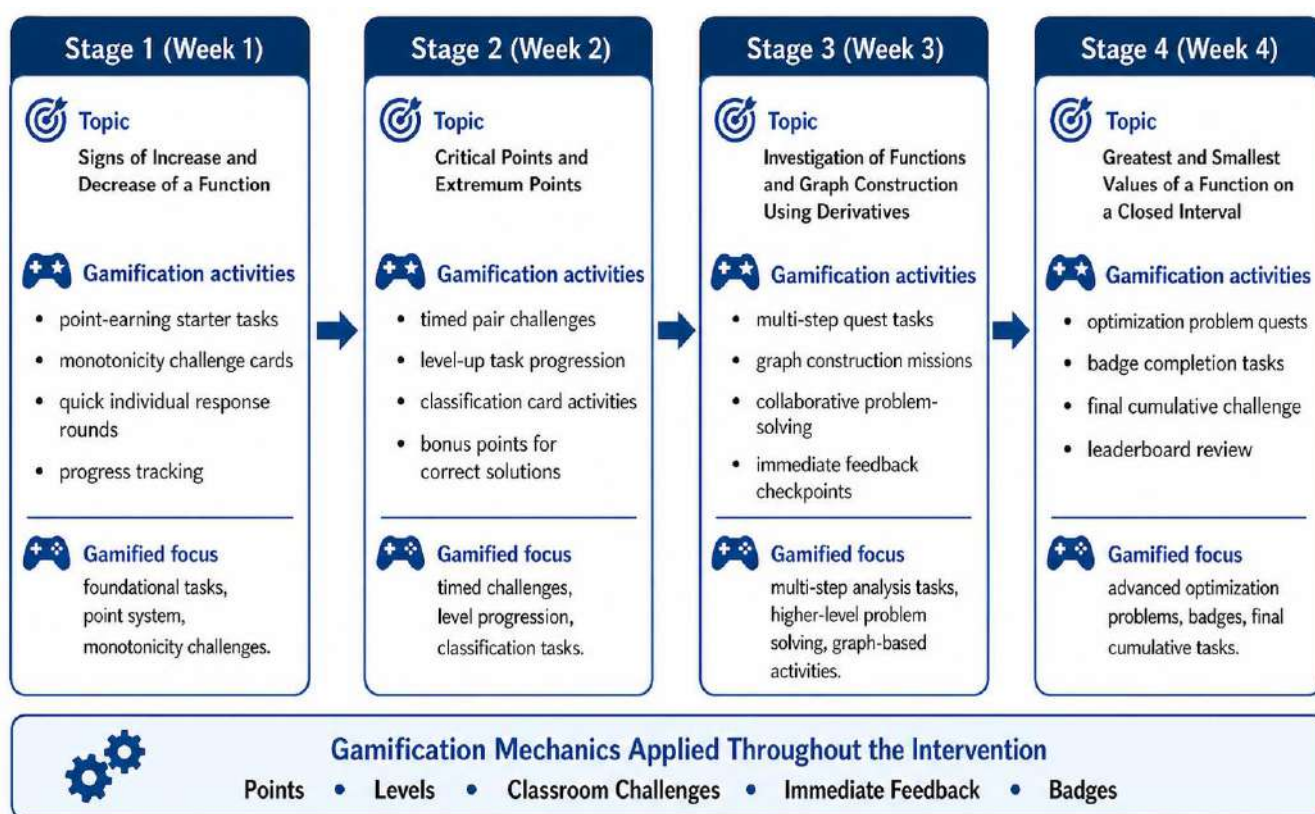
Gamified learning strategies were implemented in the experimental group during regular mathematics lessons. The purpose of the intervention was not to replace curriculum content with games, but to organize the learning process through structured gamification elements that could increase students' participation and engagement with mathematical tasks.

Several gamification strategies were incorporated into classroom instruction, including point systems, level-based progression, classroom challenges, and immediate feedback. Students earned points for correctly solving algebraic and analytical

problems related to derivatives and function analysis. Mathematical tasks were organized according to different levels of difficulty, allowing students to move gradually from simpler exercises to more complex analytical problems.

Level-based progression was used to divide learning activities into manageable stages. Students were expected to complete one level before progressing to the next set of tasks. Immediate feedback was also provided during classroom activities to help students identify mistakes and improve their problem-solving strategies throughout the learning process. Figure 3.3.1 illustrates the gamified training process that was implemented over four to five weeks.

Figure 3.3.1. Stages of Implementation of the Gamified Intervention



The intervention was organised into four sequential stages. The first stage introduced students to the relationship between the sign of the derivative and the increase or decrease of a function. The second stage focused on critical points and extremum points, allowing students to move from basic identification to classification of local maximum and minimum points. The third stage required students to integrate

previous knowledge in order to investigate functions and construct graphs using derivatives. The final stage focused on finding the greatest and smallest values of functions on a closed interval and solving applied optimisation problems.

The control group studied the same mathematical topics through traditional instruction, including teacher explanations, textbook exercises, and routine classroom practice without the use of gamified elements.

3.4 Data Collection Instruments

The data generation process relies on two distinct instruments chosen to isolate academic achievement changes and subjective gameful characteristics separately.

3.4.1 Achievement Test

The first data collection instrument used in the study was an achievement test in Algebra and the Fundamentals of Analysis. Before and after the instructional intervention, as a pre-test and post-test, the test was administered to measure students' achievement. In the test, 25 multiple-choice questions were asked on derivative-based investigation of functions such as critical points, extrema, intervals of increase and decrease, monotonicity, and maximum and minimum values. Both the pre- and post-test used the same structure and curriculum objectives to promote comparison of students' achievement scores at both data collection stages. Each correct answer was awarded one point, so the maximum possible score was 25.

The content of the test corresponded with the objectives of the curriculum of Grade 10 for the social-humanitarian direction. Specifically, the test items aligned with the learning objectives for: spotting the intervals of increase and decrease, identifying critical and extremum points, investigating functions by derivatives, constructing or interpreting the behavior of functions, and finding maximum and minimum values in a given interval. The goals were chosen because they were directly relevant to the intervention topic and the anticipated level of students in the participating classes.

The purpose of this alignment was to ensure that the instrument did not assess only factual recall, but also included questions requiring conceptual understanding,

application of procedures, analysis of function behavior, and judgment based on mathematical conditions. Since the test was designed in a multiple-choice format, the strongest representation was found in the levels of remembering, understanding, applying, and analyzing. Higher-order thinking was addressed through items requiring students to interpret derivative information, compare possible intervals, and select mathematically appropriate conclusions. To illustrate the alignment of the achievement test with Bloom's taxonomy, selected examples of test items are presented below. These examples demonstrate how the test included items addressing different cognitive levels, including remembering, understanding, applying, analyzing, and evaluation-oriented judgement. Figure 3.4.1 shows examples of remembering-level test items based on Bloom's taxonomy.

Figure 3.4.1. Example of a Remembering-Level Test Items Based on Bloom's Taxonomy

- | | |
|--|--|
| <p>1. A critical point is:</p> <p>A) $f'(x) > 0$</p> <p>B) $f'(x) < 0$</p> <p>C) $f'(x) = 0$ or the derivative does not exist</p> <p>D) $f(x) = 0$</p> <p>E) $f''(x) = 0$</p> | <p>3. An extremum point is a point at which:</p> <p>A) the function is equal to zero</p> <p>B) the function takes a maximum or minimum value</p> <p>C) the derivative is not equal to zero</p> <p>D) the graph increases</p> <p>E) the graph decreases</p> |
|--|--|

Questions 1 and 3 focus on students' basic knowledge of key concepts. Question 1 requires students to recognize the definition of a critical point, while Question 3 checks their knowledge of what an extremum point means. Figure 3.4.2 presents an example of an understanding-level test item based on Bloom's taxonomy.

Figure 3.4.2. Example of an Understanding-Level Test Item Based on Bloom's Taxonomy

- | | |
|--|---|
| <p>2. If $f'(x) > 0$, then the function:</p> <p>A) decreases</p> <p>B) is constant</p> <p>C) increases</p> <p>D) reaches a maximum</p> <p>E) reaches a minimum</p> | <p>7. If the sign of $f'(x)$ changes from $(-)$ to $(+)$, then this indicates:</p> <p>A) a maximum</p> <p>B) a minimum</p> <p>C) no extremum</p> <p>D) a constant function</p> <p>E) an interval of increase</p> |
|--|---|

For example, students need to recognize that $f'(x) > 0$ means the function is increasing, and that changes in the sign of the derivative can indicate minimum or maximum points.

The post-test was developed as an equivalent form of the pre-test. Both instruments assessed the same curriculum objectives, mathematical skills, and levels of difficulty. To reduce memorization effects, the order of questions and answer options was modified, and several numerical values and functions were slightly adjusted while preserving the conceptual structure of the tasks.

The achievement test was developed using tasks adapted from curriculum-aligned mathematics materials and textbooks used in Grade 10 Algebra and the Fundamentals of Analysis instruction. The use of a multiple-choice format also helped ensure consistency in scoring and reduced subjectivity during the evaluation process. All test items were selected and designed to correspond to the learning objectives and mathematical content covered in the official curriculum. In order to strengthen the content validity of the instrument, a round-table discussion was conducted with mathematics teachers, during which the relevance, clarity, and appropriateness of the test items were discussed collectively. In addition, both the pre-test and the post-test were reviewed by an expert in mathematics education to evaluate the alignment of the tasks with curriculum objectives and the suitability of the questions for the target student group.

3.4.2 GAMEFULQUEST

While the achievement tests capture objective cognitive outcomes, the GAMEFULQUEST scale is implemented post-intervention to operationalize and measure the experimental group's subjective psychological perceptions. Developed as a validated, multi-dimensional psychometric tool, this instrument is designed specifically to capture the distinct formative layers of a user's "gameful experience" when interacting with a non-game system, such as a flipped or gamified high school math classroom.

The questionnaire uses a standard 7-point Likert scale (ranging from 1 = *Strongly Disagree* to 7 = *Strongly Agree*). Rather than treating student engagement as a single metric, the GAMEFULQUEST instrument divides the student experience into seven distinct, psychometrically isolated subscales:

1. **Accomplishment:** Items in this subscale measure the student's perception of personal progression, reward equity, and explicit goal fulfillment within the gamified curriculum (e.g., *"The point system and badges gave me a clear sense of achievement when solving calculus problems."*).
2. **Challenge:** This dimension monitors whether the student felt the task difficulty was balanced against their emerging skill set, reflecting optimal flow states (e.g., *"The implementation of gamified learning strategies makes me feel like I continuously need to improve in order to do well."*).
3. **Competition:** This subscale tracks the psychological impact of peer comparison mechanisms, identifying whether comparative elements stimulated motivation or introduced anxiety (e.g., *"Checking my standing on the leaderboard drove me to put more effort into my mathematical tasks."*).
4. **Guidance:** Items assess the perceived clarity of the environment's structural rules, scaffolding features, and informational feedback loops (e.g., *"The gamified setup clearly guided me through the step-by-step rules of differentiation without feeling lost."*).

5. **Immersion:** Measures the depth of cognitive absorption and immediate focus generated by the gamified environment (e.g., *“When working on these algebra challenges, I became completely absorbed in the tasks and lost track of time.”*).
6. **Playfulness:** Evaluates the degree of voluntary, low-stakes exploration and organic curiosity experienced by the student (e.g., *“The gamified activities allowed me to explore mathematical concepts in a playful, experimental way.”*).
7. **Social Experience:** Tracks peer interaction, collective community-building, and collaborative dynamics during the gamified challenges (e.g., *“The gamified structure gives me a feeling of being connected to others.”*).

3.5 Data Collection Procedure

Data collection was carried out in several stages. At the beginning of the study prior to any instructional manipulation, both the experimental and control groups completed the pre-test under the same classroom conditions. The results of the pre-test were used to examine the initial achievement levels of the students and determine the comparability of the groups before the intervention.

After the pre-test, both groups were instructed on identical Grade 10 topics by the same educator to eliminate teacher-effect bias. The instructional intervention was conducted in the experimental group during regular mathematics lessons, while the control group continued learning through traditional instructional methods. The experimental group received the same curriculum through a systematically gamified design, utilizing structured points for step-by-step calculations, milestone badges for concept mastery, progressive level-scaffolding, and collaborative leaderboard feedback.

After the completion of the intervention, both groups completed the post-test under conditions similar to those of the pre-test. The collected results were then coded and prepared for statistical analysis. Following the post-test, the experimental group was given additional time to complete the GAMEFULQUEST instrument. This survey was hosted digitally to preserve anonymity and ensure unbiased feedback regarding their gameful experience.

3.6 Data Analysis

The collected data were analyzed using quantitative statistical methods. After the tests were completed, students' answers were scored according to the answer key, with one point given for each correct answer. Since the achievement test consisted of 25 multiple-choice questions, the maximum possible score was 25 points. Each student's scores were recorded using their school ID codes instead of names in order to maintain confidentiality.

The data were organized in Excel according to group, test stage, and total score. First, descriptive statistics of achievement scores were calculated for both the experimental and control groups. These included the mean, median, standard deviation, minimum score, and maximum score. This step was used to summarize students' achievement levels before and after the intervention.

Before conducting inferential statistical analysis, the normality of the data distribution was examined using the Shapiro-Wilk test. This test was selected because it is appropriate for small and moderate sample sizes. The normality analysis was conducted for the pre-test and post-test scores of both groups in order to determine whether parametric statistical tests could be applied.

After checking normality, independent samples *t*-tests and paired samples *t*-tests were used. An independent samples *t*-test was conducted to compare the pre-test scores of the experimental and control groups in order to examine whether the groups were comparable before the intervention. Another independent samples *t*-test was used to compare the post-test scores of the two groups after the intervention. Paired samples *t*-tests were conducted separately for the experimental and control groups to determine whether there were statistically significant differences between their pre-test and post-test scores.

In addition, gain scores were calculated by subtracting each student's pre-test score from the corresponding post-test score. The gain scores were used to compare the amount of improvement between the experimental and control groups. The level of statistical significance was set at 0.05 for all inferential analyses. The results were

presented in tables and interpreted in relation to the research questions and hypotheses of the study.

To answer RQ2, GAMEFULQUEST responses were analyzed using descriptive statistics. Mean scores and standard deviations were calculated for each dimension of gameful experience. Cronbach's alpha was used to examine the internal consistency of the questionnaire.

3.7 Ethical Considerations

Ethical principles were followed throughout the study. Participation in the research was voluntary, and students' identities remained confidential during all stages of data collection and analysis. The achievement test and questionnaire were conducted only for research purposes and did not affect students' official academic grades or school records.

Ethical considerations were carefully addressed before and during the data collection process. Written permission was obtained from the parents or legal guardians of all participating students, as the participants were school students and their involvement in the research required parental consent. Students were also informed that their participation was voluntary and that the collected data would be used only for research purposes.

Furthermore, at the beginning of both the achievement test and questionnaire, students were informed in written form that the assessment was not part of the official school grading system. The test instructions clearly stated that the results would not affect students' GPA, lesson grades, formative assessment, or any other official academic evaluation. This information was included to reduce possible pressure and to make clear that the purpose of the assessment was research-based rather than evaluative.

Confidentiality was also maintained through the use of student ID codes. In the participating school, students' results are commonly displayed on the notice board, but students' names are not shown; instead, each student is identified by an individual school ID code. The same procedure was applied in this study. During the pre-test and

post-test, students wrote their school ID codes instead of their names. These codes made it possible to match each student's pre-test and post-test scores while keeping their identity confidential. No student names were used in the data analysis, tables, or final reporting of the study.

All collected data were used exclusively for academic research purposes. The study was conducted in a way that minimized disruption to the regular educational process and respected the rights and well-being of all participants.

4. ANALYSIS AND FINDINGS

This chapter presents the statistical analysis of the data collected in the study. The purpose of the analysis was to examine whether the implementation of gamified learning strategies was associated with changes in students' achievement in Algebra and the Fundamentals of Analysis.

The analysis was based on the achievement scores of 58 Grade 10 students. The experimental group consisted of 29 students who received instruction through gamified learning strategies, while the control group consisted of 29 students who received traditional instruction. Student achievement was measured using a 25-item multiple-choice test administered before and after the intervention. In order to answer research questions both descriptive and inferential statistics were used to analyse the data. The chapter reports descriptive statistics, normality analysis, pre-test comparison between the experimental and control groups, within-group pre-test and post-test comparisons, and gain score comparison.

4.1 Descriptive Statistics

Descriptive statistics results are presented in Table 4.1.1.

Table 4.1.1. Descriptive Statistics for Pre-test and Post-test Achievement Scores

Group	Test	N	Mean	Median	SD
Experimental	Pre-test	29	10.28	10	3.24
	Post-test	29	17.52	17	3.34
Control	Pre-test	29	10.52	11	3.33
	Post-test	29	12.59	12	3.77

Note. The maximum score is 25.

It was calculated to summarize students' achievement scores before and after the instructional intervention. The analysis included mean scores, median values, and

standard deviations for both the experimental and control groups. The experimental group had a pre-test mean score of 10.28 and a post-test mean score of 17.52. The control group had a pre-test mean score of 10.52 and a post-test mean score of 12.59. The descriptive results show an increase in mean scores in both groups from pre-test to post-test, with a larger numerical increase observed in the experimental group.

4.2 Gain Scores

Gain scores were calculated by subtracting each student's pre-test score from the corresponding post-test score. The descriptive statistics for the gain scores are presented in Table 4.2.1.

Table 4.2.1. Descriptive Statistics for Gain Scores

Group	N	Mean Gain	Median Gain	SD	Minimum	Maximum
Experimental	29	7.24	7.00	1.83	2	11
Control	29	2.07	1.00	2.80	-6	10

Note. Gain = post-test – pre-test.

The mean gain score for the experimental group was 7.24, while the mean gain score for the control group was 2.07. The median gain score was 7.00 for the experimental group and 1.00 for the control group. The gain scores ranged from 2 to 11 in the experimental group and from -6 to 10 in the control group.

4.3 Normality Testing

Before conducting inferential statistical analysis, the distribution of the data was examined to ensure that the selected statistical methods were appropriate. Since this study used t-tests to compare students' achievement scores, it was important to check whether the data were approximately normally distributed. This is because parametric

tests, such as t-tests, rely on the assumption of normality, especially when working with relatively small sample sizes.

To evaluate this assumption, the Shapiro-Wilk test was applied to both pre-test and post-test scores in the experimental and control groups. This test was chosen because it is considered one of the most reliable methods for assessing normality in small and moderate samples. In addition to the test results, descriptive indicators such as skewness and kurtosis were also reviewed to better understand the overall shape of the data distribution. The results of the normality tests are presented in Table 4.3.1.

Table 4.3.1. Shapiro–Wilk Test of Normality

Variable	Group	W	p
Pre-test	Experimental	.974	.675
Post-test	Experimental	.987	.973
Pre-test	Control	.984	.929
Post-test	Control	.954	.238

Note. Significance level is $\alpha = .05$.

Since all p-values were greater than .05, the null hypothesis of normality was not rejected for any dataset. Therefore, the data were considered normally distributed, and parametric statistical methods, including independent samples t-tests and paired samples t-tests were used to analyze differences in achievement scores between and within the groups.

4.4 Pre-test Comparison Between Experimental and Control Groups

An independent samples *t*-test was conducted to determine whether there was a statistically significant difference between the experimental and control groups before

the intervention. This analysis was necessary to examine the baseline comparability of the two groups. The results are presented in Table 4.4.1.

Table 4.4.1. Independent Samples t-test for Pre-test Scores

Group	N	Mean	SD	t	df	p
Experimental	29	10.28	3.24	-.28	56	.781
Control	29	10.52	3.33			

Note. The maximum score is 25.

The independent samples *t*-test showed no statistically significant difference between the experimental and control groups on the pre-test, $t(56) = -.28$, $p = .781$. The mean pre-test score of the experimental group was 10.28, while the mean pre-test score of the control group was 10.52, indicating that the groups were comparable before the intervention.

4.5 Experimental Group Pre-test and Post-test Comparison

A paired samples *t*-test was conducted to examine whether there was a statistically significant difference between the pre-test and post-test scores of students in the experimental group. The results are presented in Table 4.5.1.

Table 4.5.1. Paired Samples t-test for Experimental Group Pre-test and Post-test Scores

Test	N	Mean	SD	Mean Difference	t	df	p
Pre-test	29	10.28	3.24	7.24	21.36	28	< .001
Post-test	29	17.52	3.34				

Note. The maximum score is 25.

The paired samples *t*-test showed a statistically significant difference between the pre-test and post-test scores of the experimental group, $t(28) = 21.36, p < .001$. The mean score increased from 10.28 on the pre-test to 17.52 on the post-test. The mean difference between the two scores was 7.24 points.

4.6 Control Group Pre-test and Post-test Comparison

A paired samples *t*-test was also conducted to examine whether there was a statistically significant difference between the pre-test and post-test scores of students in the control group. The results are presented in Table 4.6.1.

Table 4.6.1. Paired Samples t-test for Control Group Pre-test and Post-test Scores

Test	N	Mean	SD	Mean Difference	t	df	p
Pre-test	29	10.52	3.33	2.07	3.98	28	< .001
Post-test	29	12.59	3.77				

Note. The maximum score is 25.

The paired samples *t*-test showed a statistically significant difference between the pre-test and post-test scores of the control group, $t(28) = 3.98, p < .001$. The mean score increased from 10.52 in the pre-test to 12.59 in the post-test. The mean difference between the two scores was 2.07 points.

4.7 Post-test Comparison Between Experimental and Control Groups

An independent samples *t*-test was conducted to compare the post-test scores of the experimental and control groups. This analysis was used to examine whether students taught through gamified learning strategies demonstrated higher achievement scores than students taught through traditional instructional methods. The results are presented in Table 4.7.1.

Table 4.7.1. Independent Samples t-test for Post-test Scores

Group	N	Mean	SD	t	df	p
Experimental	29	17.52	3.34	5.27	56	< .001
Control	29	12.59	3.77			

Note. The maximum score is 25.

The independent samples t-test showed a statistically significant difference between the experimental and control groups on the post-test, $t(56) = 5.27$, $p < .001$. The mean post-test score of the experimental group was 17.52, while the mean post-test score of the control group was 12.59.

This result supports H1, which stated that students taught through gamified learning strategies will achieve statistically significantly higher post-test scores than students taught through traditional instructional methods.

4.8 Effect Size

While the inferential statistics (t-tests) successfully demonstrated that the gamified learning environment produced statistically significant improvements ($p < .001$), p-values alone do not express the magnitude or practical relevance of these differences. To evaluate the true pedagogical impact of the gamified instructional strategy, effect sizes were calculated using Cohen's d.

According to the established psychometric criteria defined by Cohen (1988), effect sizes are interpreted as small ($d = .2$), medium ($d = .5$), and large ($d = .8$). Values exceeding 1.0 indicate a remarkably robust and practically significant effect.

When comparing the summative post-test achievement between the experimental group and the control group, the analysis yielded an effect size of $d = 1.38$. This indicates a large effect, meaning that the average student in the gamified mathematics classroom scored nearly 1.4 standard deviations higher on the post-test than the average student in the traditional lecture classroom. The results are presented in Table 4.8.1.

Table 4.8.1. Effect Size Results for Achievement Test Comparisons

Comparison	Cohen's d	Interpretation
Pre-test experimental vs control	-.07	Negligible
Post-test experimental vs control	1.38	Large
Gain score experimental vs control	2.19	Very large
Experimental pre-test vs post-test	3.97	Very large
Control pre-test vs post-test	.74	Medium to large

The pre-test comparison showed a negligible effect size, indicating that the groups were comparable before the intervention. In contrast, the post-test and gain score comparisons showed large effect sizes, suggesting that the difference after the intervention was not only statistically significant but also educationally meaningful.

4.9 Dimensions of the gameful experience

To address the secondary objective of this study - evaluating how students in the experimental group actually experienced the gamified instructional intervention- the GAMEFULQUEST instrument was administered to the experimental group (N = 29) immediately following the post-test. The questionnaire measures student perceptions across seven distinctive subscales: Accomplishment, Challenge, Guidance, Playfulness, Social Experience, Immersion, and Competition. Items were rated on a 7-point Likert scale ranging from 1 (Strongly Disagree) to 7 (Strongly Agree).

The descriptive statistics and reliability coefficients for each GAMEFULQUEST dimension are summarized in Table 4.9.1. The questionnaire was completed by 29 students after the implementation of gamified learning strategies. Descriptive statistics were calculated for each GAMEFULQUEST dimension, including mean, standard deviation, minimum, and median scores.

Table 4.9.1. Descriptive Statistics for GAMEFULQUEST Dimensions

Dimensions	N	Mean	SD	Min	Median	Alpha(α)
Accomplishment	29	5.806	.685	4.25	5.75	.836
Challenge	29	5.164	.649	3.625	5	.755
Competition	29	4.576	.799	2.571	4.571	.746
Guidance	29	5.695	.629	4.143	5.714	.745
Immersion	29	5.249	.733	3.667	5.333	.828
Playfulness	29	5.295	.616	4.333	5.222	.768
Social Experience	29	5.241	.68	3.625	5.125	.735
Overall	29	5.289	.396	3.987	5.403	.882

Before interpreting the questionnaire results, Cronbach's alpha(α) was calculated to examine the internal consistency of each dimension and the overall questionnaire. A Cronbach's alpha value above 0.70 indicates acceptable reliability for educational research. Since the questionnaire used a 7-point Likert scale, mean scores above the midpoint of 4 were interpreted as indicating generally positive perceptions of the gamified learning experience. It presents the descriptive statistics for the GAMEFULQUEST dimensions among students in the experimental group. The results show that students generally perceived the gamified learning experience positively, as the overall mean score was 5.289 on a 7-point Likert scale. This indicates that the students' responses were above the midpoint of the scale and leaned toward agreement with the positive statements about the gamified intervention. The validity of GAMEFULQUEST was established through its alignment with both the study's objectives and the underlying theoretical framework.

This instrument was selected due to its design for assessing students' perceived gameful experiences in non-game contexts. The seven dimensions of

GAMEFULQUEST: accomplishment, challenge, competition, guidance, immersion, playfulness, and social experience - corresponded directly to the gamified learning strategies implemented during the intervention. Consequently, the questionnaire was deemed suitable for evaluating students' perceptions of the gamified learning experience following the intervention. Furthermore, the questionnaire's dimensions were consistent with the study's theoretical foundations, including Self-Determination Theory, Flow Theory, and Vygotsky's Zone of Proximal Development. This consistency reinforced the content validity of the instrument within the context of the present research.

Among the seven dimensions, Accomplishment received the highest mean score ($M = 5.806$, $SD = .685$). This suggests that students mainly perceived the gamified lessons as goal-oriented and achievement-focused. In other words, the use of levels, progress, and task completion may have helped students feel that they were moving forward and reaching learning goals.

The second highest dimension was Guidance ($M = 5.695$, $SD = .629$), indicating that students felt supported and directed during the gamified learning process. This result is important because it suggests that gamification did not simply make the lessons more entertaining, but also helped students understand what they needed to do and how they could improve.

The dimensions of Playfulness ($M = 5.295$, $SD = .616$), Immersion ($M = 5.249$, $SD = .733$), Social Experience ($M = 5.241$, $SD = .680$), and Challenge ($M = 5.164$, $SD = .649$) were also interpreted as positive. These results show that students experienced the gamified lessons as engaging, interactive, and appropriately challenging. The positive score for Challenge is especially relevant in mathematics learning, as it suggests that the tasks were demanding but still manageable for students.

The lowest mean score was observed for Competition ($M = 4.576$, $SD = .799$). Although this score is still above the midpoint of the scale, it was interpreted as a moderate perception. This suggests that competitive elements were less strongly experienced by students compared with other aspects of gamification. This may

indicate that students responded more positively to accomplishment, guidance, and progress-based features than to competition-based features.

The reliability coefficients for the dimensions ranged from approximately .735 to .882, except for the lowest reported value, which was still within an acceptable or usable range. This indicates that the GAMEFULQUEST dimensions showed generally acceptable internal consistency for the purposes of this study.

Table 4.9.2 presents the ranking of the GAMEFULQUEST dimensions based on their mean scores. The purpose of this table is to identify which aspects of the gamified learning experience were perceived most strongly by students in the experimental group. Accomplishment received the highest mean score ($M = 5.806$, $SD = .685$). This indicates that students most strongly perceived the gamified lessons as achievement-oriented. In other words, the use of goals, progress, levels, and task completion may have helped students feel that they were making visible progress in their learning. The second highest dimension was Guidance ($M = 5.695$, $SD = .629$). This suggests that students felt supported and directed during the gamified learning process. This result is important because it shows that gamification was not perceived only as entertainment, but also as a structured learning approach that helped students understand what to do and how to improve. The dimensions of Playfulness ($M = 5.295$, $SD = .616$), Immersion ($M = 5.249$, $SD = .733$), Social Experience ($M = 5.241$, $SD = .680$), and Challenge ($M = 5.164$, $SD = .649$) were also interpreted as positive. These results show that students generally experienced the intervention as engaging, interactive, and appropriately challenging.

The lowest-ranked dimension was Competition ($M = 4.576$, $SD = .799$), which was interpreted as a moderate perception. Although the score is still above the midpoint of the 7-point Likert scale, it suggests that competitive elements were less strongly perceived than other aspects of gamification. This may indicate that students responded more positively to progress, guidance, and achievement-based elements than to competition-based features.

Table 4.9.2. Ranking of GAMEFULQUEST Dimensions

Dimensions	Mean	SD	Interpretation
Accomplishment	5.806	.685	Positive perception
Guidance	5.695	.629	Positive perception
Playfulness	5.295	.616	Positive perception
Immersion	5.249	.733	Positive perception
Social Experience	5.241	.68	Positive perception
Challenge	5.164	.649	Positive perception
Competition	4.576	.799	Moderate perception

Overall, the ranking shows that the strongest aspects of the gamified learning experience were accomplishment and guidance, while competition was the weakest dimension. This suggests that the gamified intervention was perceived more as a structured and goal-oriented learning experience than as a purely competitive activity.

The statistical analysis indicated that both groups improved from pre-test to post-test, and these increases were statistically significant. At the beginning of the study, there was no statistically significant difference between the experimental and control groups, which suggests that the groups had similar achievement levels before the intervention. However, after the intervention, a statistically significant difference was found between the two groups. The experimental group achieved a higher mean post-test score than the control group. The gain score analysis also showed a statistically significant difference, with the experimental group demonstrating a greater increase in achievement scores.

4.10 Correlation between GAMEFULQUEST score and achievement gain score

To further examine the relationship between students' perceptions of the gamified learning experience and their academic improvement, Spearman's rank-order correlation was conducted as illustrated in Table 4.10.1. Spearman correlation was selected as GAMEFULQUEST was measured using a Likert-type scale and the sample size of the experimental group was relatively small.

Table 4.10.1. Spearman Correlation Between GAMEFULQUEST Score and Achievement Gain Score

Variable 1	Variable 2	Spearman's rho	p-value	Interpretation
GAMEFULQUEST score	Achievement gain score	.676	< .001	Strong positive correlation

Note. The analysis included only students from the experimental group (N = 29).

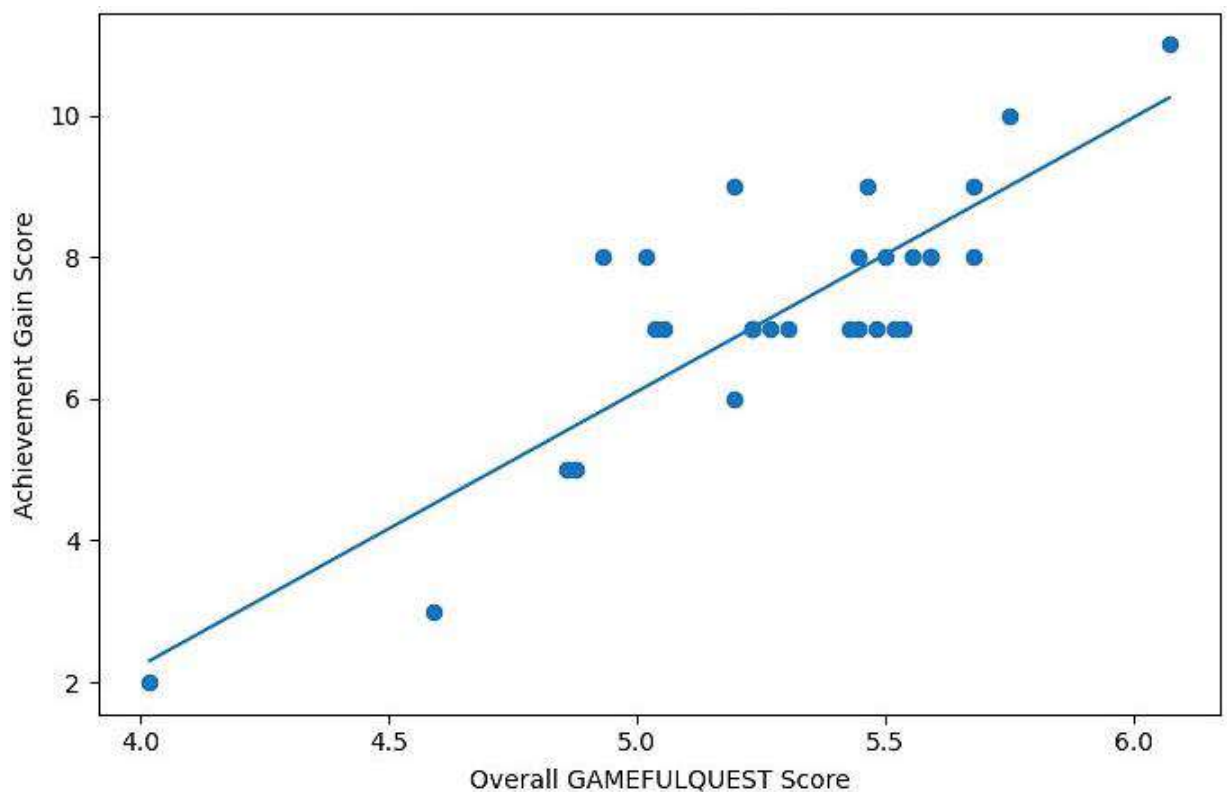
The analysis focused on the relationship between the overall GAMEFULQUEST score and students' achievement gain scores in the experimental group. The gain score was calculated by subtracting each student's pre-test score from the post-test score.

As shown in Table 4.10.1, there was a strong positive correlation between the GAMEFULQUEST score and achievement gain score, $\rho = .676$, $p < .001$. This indicates that students who reported a more positive gamified learning experience tended to demonstrate greater improvement from pre-test to post-test. However, since this analysis was correlational and involved only the experimental group, the result should be interpreted cautiously and not as evidence of direct causation. To visually illustrate this relationship, a scatter plot was created between the overall GAMEFULQUEST score and achievement gain score.

A relationship between overall GAMEFULQUEST and achievement gain scores is positively associated as seen in Figure 4.10.1. General improvement was greater for

students who positively related to the gamified learning experience from pre-test through to post-test. The horizontal axis is GAMEFULQUEST score taken on the whole, and vertical axis is achievement gain score taken on the variable post-test vs pre-test. The upward trends of the points indicate that students who had reported a more positive gamified learning experience tended to score higher on the achievement measure.

Figure 4.10.1. Scatter Plot of Overall GAMEFULQUEST Score and Achievement Gain Score



This visual finding agrees with the Spearman correlation analysis shown in Table 4.10.1, as the Spearman correlation between overall GAMEFULQUEST score and achievement gain score also reached a high level, $\rho = .676$, $p < .001$. Thus, the scatter plot validates the interpretation that favorable learning experience of gamified learning of students was significantly associated with their improving in academic subjects. Since this analysis is correlational and included the experimental group only, the relationship should not be interpreted as direct causation.

5. DISCUSSION AND CONCLUSION

5.1 Overview of the Study

This quasi-experimental study examined the empirical effects of gamified learning strategies on Grade 10 students' academic achievement in Algebra and the Fundamentals of Analysis. Additionally, the study assessed students' psychological perceptions of the gameful environment. Both groups studied derivative subjects: critical points, extrema, monotonicity, intervals of increase and decrease, and maximum and minimum values of functions. The main difference between the two groups was the instructional strategy: the experimental group learned by a gamified method, while the control group was taught by a traditional instruction.

The results showed that both groups improved from pre-test to post-test. However, the improvement in the experimental group was greater than the improvement in the control group. The experimental group's mean score increased from 10.28 to 17.52, while the control group's mean score increased from 10.52 to 12.59. The post-test comparison showed a statistically significant difference in favour of the experimental group, $t(56) = 5.27$, $p < .001$, with a large effect size, Cohen's $d = 1.38$. Furthermore, the GAMEFULQUEST results also indicated that students generally perceived the gamified learning experience positively. The strongest dimensions were Accomplishment and Guidance, while Competition received the lowest mean score. These findings suggest that the value of gamification in this study was not limited to entertainment. Rather, gamification appeared to function as a structured pedagogical approach that supported students' progress, engagement, and understanding of cognitively demanding mathematical content.

5.2 Discussion of Research Question 1

Research Question 1: To what extent do gamified learning strategies affect Grade 10 students' achievement in Algebra and the Fundamentals of Analysis compared with traditional instruction?

The findings of this study indicate that gamified learning strategies had a positive effect on Grade 10 students' achievement in Algebra and the Fundamentals of Analysis. Before the intervention, the experimental and control groups had similar achievement levels. The independent samples t-test for the pre-test scores showed no statistically significant difference between the two groups, $t(56) = -0.28$, $p = .781$. The experimental group had a mean pre-test score of 10.28, while the control group had a mean pre-test score of 10.52. This suggests that the two groups were comparable before the implementation of the instructional intervention. Inferential statistical analysis provided strong evidence that integrating structural gamification strategies significantly enhances academic performance.

After the intervention, both groups improved from pre-test to post-test. However, the improvement in the experimental group was considerably greater. The experimental group's mean score increased from 10.28 to 17.52, representing a mean gain of 7.24 points. In contrast, the control group's mean score increased from 10.52 to 12.59, representing a mean gain of 2.07 points. Since the achievement test consisted of 25 items, the experimental group's mean gain corresponds to approximately 29 percentage points of the total test score. This indicates a meaningful improvement in students' ability to solve derivative-based problems after learning through gamified instruction.

The post-test comparison also showed a statistically significant difference in favour of the experimental group. The independent samples t-test revealed that students in the experimental group achieved significantly higher post-test scores than students in the control group, $t(56) = 5.27$, $p < .001$. The experimental group's mean post-test score was 17.52, while the control group's mean post-test score was 12.59. These results support the first research hypothesis and allow the rejection of the first null hypothesis.

Cohen's d was calculated to assess the practical educational value of the intervention. The resulting effect size (for the post-test comparison $d = 1.38$ which is interpreted as a large effect) indicates a substantial instructional impact, with the

average student in the gamified classroom achieving performance scores nearly 1.4 standard deviations higher than the average student in the traditional lecture setting. In addition, the effect size for the gain score comparison was reported as 2.19, which further suggests that the experimental group demonstrated substantially greater learning progress than the control group.

The results may be explained by the gamified intervention structure. Derivative-based function analysis is cognitively demanding because students need to connect symbolic procedures with conceptual and graphical reasoning. They must understand the relationship between the sign of the derivative and function behaviour, identify critical points, determine extrema, analyse monotonicity, and solve maximum and minimum value problems. Many Grade 10 students find these tasks hard as they involve procedural fluency and conceptual knowledge at the same time.

In the experimental group, it may be that points, levels, problems they received in the classroom or immediate feedback may have guided students to approach these difficult tasks in a more systematic way. Rather than treating the whole subject as a single large and abstract unit, students worked through several smaller stages of learning. This progression by level may have made complex mathematics work seem less difficult to tackle because it was broken down into more manageable steps. Moreover, if intermediate steps were rewarded, rather than just final answers, learners might have been motivated to keep moving, to correct errors and to move through difficult problems.

These findings are consistent with previous research suggesting that gamification can support mathematics achievement when it is carefully connected to learning objectives rather than used only as entertainment. Attard and Holmes (2022) highlighted the impact of gamification on promoting student engagement with mathematics learning in an educational context, whilst Karamert and Kuyumcu Vardar (2021) observed a positive relation between gamification and mathematics achievement. The current study explores the gamified teaching techniques in the context of Grade 10 Algebra and the Fundamentals of Analysis in Kazakhstan,

particularly within derivative-based function analysis, which remains less represented in the existing literature for the field of gamification and thus adds to this literature.

The results could also be interpreted in terms of Self-Determination Theory. The gamified format may also have supported students' feelings of competence in this scenario, as they could record gains based on points, levels, and task completion. The instant feedback also let students know what they did right and where they needed to grow. The level-based system may have also enhanced autonomy, as students might have been given the opportunity to progress step by step. A relatedness of shared learning experience among students can be fostered by classroom challenges and collaborative components. Flow Theory might also explain the results to some extent. Tasks in a gamified learning environment can be grouped by increasing difficulty. This might help to ensure that they stay on a level between currently competent and challenged within students. If tasks are too easy, students can get bored; if tasks are too difficult, they can become anxious or disengaged. The design of the intervention to be level-based might enable students to stay engaged with challenges which were challenging and yet attainable. Vygotsky's Zone of Proximal Development is also applicable for interpreting this. The gamified activities acted similar to scaffolding, as students progressed from easy to difficult mathematical problems with assistance from teachers, peers and feedback. In other words, once students mastered one level, they could move on to the next level.

Thus, gamification functioned more as an instructional framework that fostered the development of mathematics gradually than as a motivational device. Traditional instruction did not fail, so we should emphasize that it was effective. The control group also had statistically significant improvement from pre-test to post-test, suggesting that students also learned through formal instruction. However, improvements in the control group were less than the experimental group. Thus, the results should not be taken as proof that classic teaching cannot produce an effect. A more accurate interpretation would be that both approaches supported learning, however, the study found stronger gains in achievement in the case of gamified instruction. As a whole,

the response to Research Question 1 is that gamified learning strategies had a statistically significant and educationally meaningful positive effect on Algebra and Fundamentals of Analysis achievement of Grade 10 students compared to regular instruction.

5.3 Discussion of Research Question 2

Research Question 2: How do students in the experimental group perceive the gamified learning experience after the intervention?

The GAMEFULQUEST results showed that in general the gamified learning experience was positively perceived by the students of the experimental group. The overall mean score was 5.289 on a 7-point Likert scale, which is above the scale midpoint of 4. This demonstrates that students reacted positively to claims made on positive aspects about this gamified learning experience. Internal consistency of the general questionnaire was also excellent with Cronbach's alpha = .882.

Among the seven dimensions, Accomplishment had the highest mean score, $M = 5.806$, $SD = .685$. This suggests that students most strongly experienced gamification as a system that helped them feel progress, achievement, and goal completion. This is an important finding because it shows that the gamified intervention was not perceived mainly as play or entertainment. Instead, students appeared to value the sense of moving forward and reaching learning goals.

Guidance was the second highest, $M = 5.695$, $SD = .629$. This outcome is especially meaningful for mathematics learning. Algebra and the Fundamentals of Analysis includes abstract and challenging content, and students often need clear structure when learning derivatives, extrema, monotonicity, and optimisation problems. The high score for Guidance suggests that the gamified structure helped students understand what they needed to do, how to proceed, and how to improve. Therefore, the strongest part of the intervention appears to be its structured learning pathway.

Playfulness, Immersion, Social Experience, and Challenge dimensions were also positively rated. Playfulness scored the most with a mean score of 5.295,

Immersion scored 5.249, Social Experience a mean score of 5.241 and Challenge had 5.164. The results indicate that the students found the lessons to be engaging, interactive and of a reasonable demanding nature in their interactions. The positive Challenge score is significant as it explains that students are not viewing that the tasks are too easy or pointless. Instead, they were hard-to-do but still manageable activities. The mean score of Competition was the lowest dimension, $M = 4.576$, $SD = 0.799$. This is still above the mid-point, but lower than all other dimensions. This indicates the students react less favorably to competition than to achievements, instructions and progress. This result is significant since it challenges the often oversimplified view that gamification is primarily about competition, leaderboards and winning. The more important educational elements of gamification based upon this analysis seemed to be structure, progress, feedback and achievement.

From the perspective of SDT, excessive competition can sometimes create pressure and reduce intrinsic motivation, especially for students who are less confident in mathematics. The relatively lower Competition score may therefore be interpreted positively: the intervention was not experienced as overly competitive. Instead, students seemed to perceive it more as a guided and achievement-oriented learning environment. This is especially relevant in mathematics classrooms, where strong competition can increase anxiety for some students.

The additional Spearman correlation analysis showed a strong positive relationship between the overall GAMEFULQUEST score and students' achievement gain scores in the experimental group, $\rho = .676$, $p < .001$. This indicates that students who reported a more positive gamified learning experience tended to demonstrate greater improvement from pre-test to post-test. However, this result should be interpreted cautiously because the analysis was correlational and included only students from the experimental group. Therefore, the correlation does not prove that positive perception caused achievement gains. Rather, it suggests that students' subjective experience of gamification and their academic improvement were meaningfully related in this sample.

Therefore, the answer of the Research Question 2 is that students perceived the gamified learning experience positively, especially in terms of Accomplishment and Guidance. The results suggest that students valued the clear structure, visible progress, and goal-oriented nature of the gamified lessons more strongly than competitive features. The correlation analysis further suggests that students who experienced the intervention more positively also tended to show greater achievement gains, although this relationship should not be interpreted as causal.

5.4 Theoretical Implications

The results of this study support the theoretical argument that gamification may affect learning when it is embedded into significant psychological and pedagogic processes.

First, the findings are consistent with SDT. SDT would predict higher levels of motivation and more meaningful learning when autonomy, competence, and relatedness are maximized. The high scores for Accomplishment and Guidance suggest that students experienced the gamified environment as supportive of progress, goal achievement, and structured learning. These elements are closely related to students' sense of competence. Classroom challenges and collaborative activities may also have supported relatedness, while level-based progression might have provided students with a clearer sense of movement through the learning process.

Secondly, the results can be linked to Flow Theory. The positive results for Challenge and Immersion suggest the gamified activities might have established a learning environment where students were able to learn something hard, but at the same time not impossible. Achieving this balance is crucial for derivative-based topics and if a topic is too simple or too difficult, students become easily demotivated.

A third reason is that the results provide evidence of the applicability of Vygotsky's Zone of Proximal Development to gamified mathematics education. It provided a level of scaffolding by moving students from simple derivative work to more complex function analysis and optimisation problems. It indicates that

gamification may be more than a ‘motivation drive’ but also as a means to structure mathematical learning in students’ ‘target development level’.

The study also contributes to the literature by showing that gamification can be applied to upper-secondary mathematics, not only to younger learners or simpler mathematical topics. Whereas many studies of gamification concentrate on general engagement or lower-level mathematics, this study focused on Grade 10 Algebra and the Fundamentals of Analysis, including derivative-based topics. Therefore, the findings extend the discussion of gamification to a more cognitively demanding area of school mathematics.

The results of this study support the theoretical argument that, when linked with meaningful psychological and pedagogical mechanisms, gamification can impact learning. This study results have several important theoretical implications.

5.5 Practical Implications for Mathematics Education in Kazakhstan

The findings have practical implications for mathematics instruction at the upper-secondary level in Kazakhstan. Specifically, the results indicate that gamified learning strategies can serve as an effective pedagogical approach in Algebra and the Fundamentals of Analysis, particularly when students are engaging with cognitively demanding topics such as derivative-based function analysis.

For classroom teachers, the results indicate that gamification does not require replacing mathematical content with games. Rather, teachers can structure existing curriculum tasks using points, classroom challenges, levels, immediate feedback, and progress tracking. The level-based progression model employed in this study is particularly practical, as it enables teachers to divide problem sets into multiple levels of difficulty and guide students from simpler to more complex tasks.

The findings further indicate that teachers should prioritize accomplishment, guidance, and visible progress over competition. According to the GAMEFULQUEST results, students rated Accomplishment and Guidance higher than Competition. Consequently, gamification should not be limited to leaderboards

or student rankings. In mathematics classrooms, particularly where students possess varying levels of preparation, excessive competition may discourage less-prepared students. A more balanced approach would emphasize personal progress, feedback, mastery, and collaborative learning.

For school curriculum coordinators and administrators, the study provides evidence that gamified instruction can support student-centred learning goals within the Kazakhstani curriculum. As many gamification elements can be implemented using low-cost tools such as printed task cards, progress sheets, badges, and classroom challenges, this approach remains feasible even in contexts with limited digital infrastructure.

For educational policymakers, the study illustrates how interactive instructional strategies can advance the broader objective of increasing student engagement in mathematics. However, effective implementation requires accompanying teacher training, as gamification is successful only when game elements are explicitly aligned with learning objectives rather than serving as superficial entertainment.

5.6 Conclusion

The current quasi-experimental study examined the impact of gamified learning strategies on Grade 10 students' performance in Algebra and the Fundamentals of Analysis. The participants' perception of the gamified learning experience was also assessed using the GAMEFULQUEST questionnaire. The intervention was based on derivative concepts such as critical points, monotonicity, extrema; intervals of increase and decrease; and maximum and minimum values of functions. Results showed that the experimental and control groups demonstrated improvement from pre-test to post-test. But the experimental group performed better. The mean score of the experimental group increased from 10.28 to 17.52 and that of the control group improved from 10.52 to 12.59. Based on the post-test results, the experimental group had a statistically significant difference, $t(56) = 5.27$, $p < .001$ (large effect size, Cohen's $d = 1.38$). Such results imply that gamified learning strategies contributed significantly positively to students' achievement in this study.

Overall, students reported positive perceptions of the gamified environment on the GAMEFULQUEST. The overall mean score was 5.289 on a 7-point Likert scale. The greatest scores were for Accomplishment, $M = 5.806$, and Guidance, $M = 5.695$. This is an indication that students appreciated progress, achievement of goals, structure, and support from the gamified lessons. We found competition to have the lowest mean score, $M = 4.576$, which still was above the midpoint of the scale. This suggests that students reacted better to progress-based and guidance-based elements versus competition-based elements. Exploratory correlation analyses also indicated a considerable positive correlation between students' overall GAMEFULQUEST scores and their achievement gain scores, $\rho = .676$, $p < .001$. This indicates that students who enjoyed the gamification of the learning experience had more improvement as well. However, as this was a correlational analysis, specifically based on the experimental group at the end of the study to be compared, it is not to be interpreted as evidence for causation. Nevertheless, this study provides evidence for possible success of gamified approaches and makes possible a positive learning experience for students of Algebra and Fundamentals of Analysis in Grade 10.

The results indicate that gamification is beneficial when it is conceptualized as part of a formal instructional strategy rather than as an entertainment tool. In particular, various features like points, levels, instant feedback, time-varying feedback with real-time progress monitoring, and clarity in goals could force students to interact actively with challenging math content.

6. LIMITATIONS

6.1 Limitations of the Study

Several limitations of this study need to be recognised when interpreting its results. These limitations are related to the research design, sample size, intervention duration, content scope, measurement instruments, and the type of data collected.

Quasi-experimental design. Because the study was a quasi-experimental research design conducted in a real school setting with already established Grade 10 classes. As such, individual students could not be randomly assigned to the experimental and control groups. While pre-test results demonstrated that the two groups were statistically equivalent prior to the intervention, some unmeasured factors may have affected this finding. For instance, students' previous learning behaviours, confidence in mathematics, differences of motivation, support at home, or private tutorial assistance may have influenced their performance within the study. Therefore these results should be interpreted as evidence of an association between gamified instruction and achievement improvement, not definite proof of causation.

Sample size. The total sample size of 58 students is small. Although the sample size was adequate to detect the large effect sizes observed in this study, it might not have done it, or be enough to detect smaller effects or to support strong subgroup analyses. The findings should be confirmed to ensure that replication with larger and more diverse samples will support the findings.

Short intervention duration. The intervention lasted between four and five weeks, allowing for important short-term benefits in the immediate term, but it does not permit conclusions to be drawn about long-term effects of gamification on achievement or motivation. Thus it's possible that novelty effects played a role in the experimental group's gains in performance, and that over a longer period of time such effects would diminish. Longitudinal studies are needed to see what are the effects of sustained gamification over the course of one academic year.

Content scope. The intervention aimed at a unit of the Grade 10 Algebra and Fundamentals of Analysis curriculum - derivative-based investigation of functions. These findings cannot be generalized to other elements in the course, including exponential functions, trigonometry or integral calculus, all of which are complex in concept and motivation. Future research should expand the gamification effect on a wider curriculum range. Different mathematical topics may require different forms of gamified instruction.

Measurement instrument. The achievement test was a researcher-developed instrument. Content validity was ensured through expert review and with respect to the curriculum; however, not having an independently validated instrument reduces the scope for comparison with other studies. In addition, the test consisted of multiple-choice items, which may not fully capture students' deeper conceptual understanding, mathematical reasoning, or ability to explain their solutions.

Absence of motivation data. The study measured academic achievement and students' perceptions of the gamified learning experience through GAMEFULQUEST. However, it did not include separate validated measures of motivation, self-efficacy, or mathematics anxiety. Therefore, although the discussion interprets the findings through Self-Determination Theory, Flow Theory, and the Zone of Proximal Development, the study cannot directly prove that achievement improved because of increased motivation, reduced anxiety, or stronger self-confidence.

6.2 Recommendations for Future Research

Several recommendations can be made for future research based on the findings and limitations of this study.

Future studies should include larger and more diverse samples, including students from rural and urban schools, different socioeconomic backgrounds, and different regions of Kazakhstan. Such diversity would make it possible to examine whether the positive effects of gamification observed in the present study can be generalized to a wider educational context.

In addition, future research would benefit from a longitudinal design conducted over a full academic year, as this would provide a clearer understanding of whether the effects of gamification are sustained over time rather than limited to short-term improvement. In particular, it would be crucial to investigate if gains in achievement gained through the intervention are sustained over time, or if persistent use of gamified instruction results in a greater effect and diminished through exposure to these novelty effects.

Third, future research would be wise to use scientifically-validated measurements of student motivation, self-efficacy, and mathematics anxiety together with achievement tests. This would enable researchers to test theoretical mediation models suggested by self-determination and flow theories, and unpack which cognitive and motivational processes lead to gamification impacting achievement.

Fourth, combining quantitative measures of achievement with qualitative exploration of student experience would add to our understanding of student interactions with gamified instruction. Interviews with students, focus groups with students and classroom observation could reveal which particular gamification process was most exciting and beneficial to them and thus, can give a richer picture than just performance scores alone.

Fifth, future studies could look more closely at which parts of gamification actually make the greatest difference. This would help clarify which features are most useful for different student groups and classroom contexts.

Sixth, next, researchers need to study the best length and degree of gamification interventions. The current study utilized an intervention with a duration of four to five weeks; it is unclear whether the results would be similar, larger, or smaller with shorter or longer intervention. Dose-response research exploring the time of intervention relative to its resulting intervention effects would be used to make real-world determinations around the proportion of the curriculum that should move through gamified learning activities.

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LIST OF APPENDICES

APPENDIX A – A Test for Assessing Participants' Achievement Level in Algebra and the Fundamentals of Analysis Pre-test and Post-test

- Келісемін

ID: _____

Зерттеу жобасы: Геймификацияланған оқыту стратегияларының алгебра және анализ бастамалары бойынша студенттердің үлгеріміне әсері

Оқушыларға арналған маңызды ақпарат:

Мақсаты: **Бұл тест тек зерттеу мақсатына ғана арналған.** Мақсаты - біздің сыныптағы жаңа оқыту әдістері мен ойынға негізделген оқу құралдарының тиімділігін бағалау.

Бағалау үшін емес: Бұл бағалау ресми мектеп емтиханы емес. Нәтижелер сіздің ресми бағалар журналыңызға жазылмайды және сіздің осы мектептегі қорытынды курс бағаңызға, GPA-ңызға немесе академиялық көрсеткіштеріңізге әсер етпейді. Сіздің жеке ұпайларыңыз құпия болып қалады және зерттеуші оқыту стратегиясының тиімділігін талдау үшін ғана пайдаланады. Сіздің атыңыз ешқашан қорытынды зерттеу есебінде пайдаланылмайды. Сұрақтарға мүмкіндігінше дәл жауап беріңіз.

1. Кризистік нүкте дегеніміз:

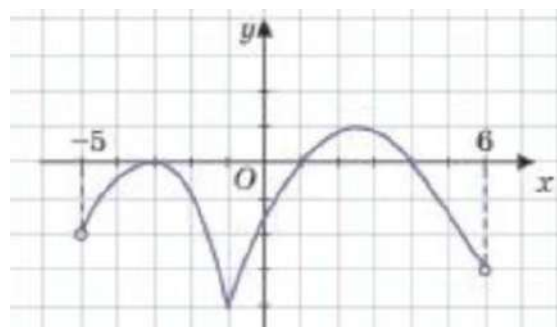
- A) $f'(x) > 0$
- B) $f'(x) < 0$
- C) $f'(x) = 0$ немесе анықталмаған
- D) $f(x) = 0$
- E) $f''(x) = 0$

2. Егер $f'(x) > 0$ болса, онда функция:

- A) кемиді
- B) тұрақты
- C) өседі
- D) максимумға жетеді
- E) минимумға жетеді

3. Экстремум нүктесі дегеніміз:

- A) функция нөлге тең
- B) функция максимал немесе минимал мән қабылдайды
- C) туынды нөлге тең емес
- D) график өседі
- E) график кемиді



4. Суретте $f(x)$ функциясының туындысының графигі көрсетілген. Олай болса, $f(x)$ функциясының $[-5; 6]$ аралығындағы барлық экстремум нүктелерін табыңыз.

- A) $x_{\max} = 1; x_{\min} = 4$
- B) $x_{\max} = -3$
- C) $x_{\max} = -3; x_{\min} = -1$
- D) $x_{\min} = -3$
- E) $x_{\max} = 4; x_{\min} = 1$

5. $f(x) = x^2 - 2x + 3$ функциясы:

- A) тек өседі
- B) тек кемиді
- C) алдымен кемиді, кейін өседі

D) тұрақты

E) анықталмаған

6. Функцияның нөлдерін табыңыз:

$$f(x) = \frac{(x-3)(x+5)}{x-6}$$

A) $x = -5; 3; 6$

B) $x = 5; 6$

C) $x = -3; 5$

D) $x = -5; 3$

E) функцияның нөлдері жоқ

7. $f'(x)$ таңбасы $- \rightarrow +$ ауысса:

A) максимум

B) минимум

C) жоқ

D) тұрақты

E) өседі

8. $f'(x)$ таңбасы $+ \rightarrow -$ ауысса:

A) максимум

B) минимум

C) жоқ

D) үзіліс

E) түзу

9. $f(x) = x^2 - 2x + 3$ өсу аралығы:

A) $(-\infty; 1)$

B) $(1; +\infty)$

C) $(0; 1)$

D) $(-1; 1)$

E) $(-\infty; +\infty)$

10. $f(x) = 2x^3 - 15x^2 + 36x - 14$
экстремум саны:

A) 0

B) 1

C) 2

D) 3

E) 4

11. $f(x) = x - 4\sqrt{x}$ функциясының
кему аралығы:

A) $(0; 4)$

B) $(4; +\infty)$

C) $(-\infty; 4)$

D) $(0; +\infty)$

E) жоқ

12. $f(x) = x^4 - 4x + 5$ минимум
мәні:

A) 1

B) 3

C) 5

D) 0

E) 2

13. Функцияның өсу және кему
аралықтарын табыңыз: $f(x) = \frac{x}{2} -$

$$\frac{2}{x}$$

A) $[-1; +\infty)$ аралығында функция
өседі, ал $(-\infty; -1]$ аралығында кемиді.

B) $(-\infty; 0] \cup [2; +\infty)$ аралығында
функция өседі, ал $[0; 2]$ аралығында
кемиді.

C) $[1; +\infty)$ аралығында функция
өседі, ал $(-\infty; 1]$ аралығында
кемиді.

D) $(-\infty; 0) \cup (0; +\infty)$ аралығында өседі,
ал кему аралығы жоқ.

E) өсу аралығы жоқ, $(-\infty; 0) \cup (0; +\infty)$
аралығында кемиді.

$$14. f(x) = \cos x - \frac{1}{3} \cos 3x$$

функциясының $[0; \frac{\pi}{2}]$ кесіндісіндегі
ең үлкен және ең кіші мәндерін
табыңыз:

$$A) \frac{3\sqrt{2}}{4}; 0$$

B) $\frac{2\sqrt{2}}{5}; 0$

C) $\frac{2\sqrt{2}}{3}; 0$

D) $\frac{\sqrt{2}}{3}; 0$

E) $\frac{\sqrt{2}}{5}; 0$

15. $f(x) = 2\sin x + \cos 2x$

функциясының максимум мәні:

A) 1

B) 2

C) $\frac{3}{2}$

D) $\frac{4}{3}$

E) $\frac{5}{3}$

16. Көрсетілген аралықтардың қайсысында $f(x) = \sqrt{x - x^2}$ функциясы монотонды өспелі?

A) $[-\frac{1}{2}; 1]$

B) $[\frac{1}{2}; +\infty)$

C) $[0; \frac{1}{2}]$

D) $(-\infty; 0]$

E) $[-2; 1]$

17. $f(x) = x^2(2x - 3) - 12(3x - 2)$

функциясының экстремум саны:

A) 1

B) 2

C) 3

D) 0

E) 4

18. $f(x) = x^5 - 15x^3 + 8$

максимум нүктесі:

A) 0

B) 3

C) -3

D) 1

E) -1

19. Функцияның экстремум

нүктелерін табыңыз:

$f(x) = x^2 - 10x + 3$

A) $x_{max} = 3$

B) $x_{min} = 5$

C) $x_{max} = 5$

D) $x_{min} = 3$

E) $x_{max} = 2$

20. $f(x) = 16x^3 - 24x^2 + 9x - 1$

функциясының кему

интервалындағы x -тің бүтін мәндерінің санын табыңыз.

A) 4

B) 3

C) 1

D) 2

E) 0

21. Функцияның өсу аралығын

табыңыз: $f(x) = 2x^3 - 3x^2 - 12x$

A) $[-1; 1]$

B) $[0; +\infty)$

C) $(-\infty; 1] \cup [2; +\infty)$

D) $(-\infty; 0]$

E) $(-\infty; -1] \cup [2; +\infty)$

22. $f(x)$ функциясының туындысы мынаған тең:

$$f'(x) = (x^2 - 1)(x^2 - 9)(x^2 - 16)$$

Онда оның кему аралықтарының ұзындығының қосындысын табыңыз.

- A) 1
- B) 2
- C) 3
- D) 4
- E) 5

$$23. f(x) = x^2 - 4x + 1$$

функциясының $\max = 1$ болатын аралығы:

- A) (0; 4]
- B) (0; 8]
- C) (0; 6]
- D) (0; 5]
- E) (0; 2]

24. [1; 3] аралығында

$$f(x) = -x^3 + 3x^2 + 5$$

функциясының ең үлкен және ең кіші мәндерінің қосындысы:

- A) 12
- B) 14
- C) -9
- D) 8
- E) 15

25. Туынды әдісі не үшін қолданылады?

- A) тек график
- B) үлкен/кіші мәндерін табу үшін ғана
- C) функцияны толық зерттеу
- D) экстремум нүктелерінің орналасуын анықтау үшін
- E) тек теңдеу

APPENDIX B - Informed Consent Form

Project Title: The Impact of Gamified Learning Strategies on Student Achievement in Algebra and the Fundamentals of Analysis

Researcher: Assemgul Gubasheva

Introduction

You and your child are invited to participate in a research study investigating the impact of gamification on mathematics education. Before deciding to participate, it is important that you understand why the research is being done and what it will involve. Please read this form carefully and ask any questions you may have.

Purpose of the Study

The primary purpose of this study is to evaluate the effectiveness of gamified learning in enhancing student achievement in tenth-grade Algebra and the Fundamentals of Analysis. By analyzing the results, this research seeks to determine if gamified learning strategies can be a valuable tool for teachers in Kazakhstan to improve student academic outcomes in these subjects.

Procedures

If you agree to have your child participate, the following will occur over a period of 4-6 weeks:

1. **Pre-test:** Students will complete a mathematics assessment to establish a baseline of their current knowledge.
2. **Gamified Instruction:** Students will participate in regular Algebra and Fundamentals of Analysis lessons where some applications are used to track progress, award points for participation, and provide immediate feedback and other tools also be used.
3. **Post-test:** At the end of the instructional period, students will complete a final assessment to measure learning gains.
4. **Questionnaire:** After the completion of the gamified learning intervention, students in the experimental group will complete the Gameful Experience Questionnaire (GAMEFULQUEST). This questionnaire is designed to measure students' perceptions of the gamified learning experience. It includes statements related to seven dimensions: accomplishment, challenge, competition, guidance, immersion, playfulness, and social experience. Students will answer the statements using a 7-point Likert scale, where 1 means "Strongly Disagree" and 7 means "Strongly Agree."

Risks and Benefits

The risks associated with this study are minimal and no greater than those encountered in a typical classroom environment. Benefits include the potential for increased engagement and achievement in mathematics. Furthermore, the findings may help educators in Kazakhstan develop more effective digital teaching strategies.

Confidentiality

All information collected will be kept strictly confidential. Students' names will be replaced with their school ID in all data records to ensure anonymity. Data will be stored on a password-protected device and will only be accessible to the researcher. Per academic regulations, data will be retained for 3 years before being destroyed.

Voluntary Participation

Participation is entirely voluntary. Your child may withdraw from the study at any time without any penalty or impact on their grades or relationship with the school.

Contacts and Questions

If you have questions regarding this study, you may contact:

- **Researcher:** Assemgul Gubasheva at 241105006@sdu.edu.kz
-

STATEMENT OF CONSENT**Parent/Guardian Consent:**

I have read the information provided above. I have had the opportunity to ask questions and have received satisfactory answers. I consent to my child's participation in this study.

Parent/Guardian Signature

Date

Student Assent:

I understand what I will be asked to do in this study. I agree to participate and understand that I can stop at any time.

Student Signature

Date

APPENDIX C - GAMEFULQUEST Questionnaire

Gameful Experience Questionnaire

- I agree

ID: _____

Research Project: The Impact of Gamified Learning Strategies on Student Achievement in Algebra and the Fundamentals of Analysis

Important Information for Students:

Purpose: This test is intended for research purposes only. Its purpose is to evaluate the effectiveness of new teaching methods and game-based learning tools used in our class.

Not for grading: This assessment is not an official school examination. The results will not be recorded in your official school gradebook and will not affect your final course grade, GPA, or academic performance at this school. Your individual scores will remain confidential and will be used by the researcher only to analyze the effectiveness of the teaching strategy. Your name will never be used in the final research report.

Please answer the questions as accurately as possible.

Instruction: Please indicate how much you agree with each of the following statements regarding your feelings during the implementation of gamified learning strategies. For each statement, place a check mark (✓) in the corresponding box that best represents your opinion.

Overall, the implementation of gamified learning strategies...

7-Point Likert Scale

	1	2	3	4	5	6	7
	Strongly Disagree	Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Agree	Strongly Agree

Dimension 1: Accomplishment (8 items)

Item	1	2	3	4	5	6	7
1. Makes me feel that I need to complete things.							
2. Pushes me to strive for accomplishments.							
3. Inspires me to maintain my standards of performance.							
4. Makes me feel that success comes through accomplishments.							
5. Makes me strive to take myself to the next level.							
6. Motivates me to progress and get better.							

7. Makes me feel like I have clear goals.							
8. Gives me the feeling that I need to reach goals.							

Dimension 2: Challenge (8 items)

Item	1	2	3	4	5	6	7
1. Makes me push my limits.							
2. Drives me in a good way to the brink of wanting to give up.							
3. Pressures me in a positive way by its high demands.							
4. Challenges me.							
5. Calls for a lot of effort in order for me to be successful.							
6. Motivates me to do things that feel highly demanding.							
7. Makes me feel like I continuously need to improve in order to do well.							
8. Makes me work at a level close to what I am capable of.							

Dimension 3: Competition (7 items)

Item	1	2	3	4	5	6	7
1. Feels like participating in a competition.							
2. Inspires me to compete.							
3. Involves me with its competitive aspects.							
4. Makes me want to be in first place.							
5. Makes victory feel important.							
6. Feels like being in a race.							
7. Makes me feel that I need to win to succeed.							

Dimension 4: Guidance (7 items)

Item	1	2	3	4	5	6	7
1. Makes me feel guided.							

2. Gives me a sense of being directed.							
3. Makes me feel like someone is keeping me on track.							
4. Gives me the feeling that I have an instructor.							
5. Gives me the sense I am getting help to be structured.							
6. Gives me a sense of knowing what I need to do to do better.							
7. Gives me useful feedback so I can adapt.							

Dimension 5: Immersion (9 items)

Item	1	2	3	4	5	6	7
1. Gives me the feeling that time passes quickly.							
2. Grabs all of my attention.							
3. Gives me a sense of being separated from the real world.							
4. Makes me lose myself in what I am doing.							
5. Makes my actions seem to come automatically.							
6. Causes me to stop noticing when I get tired.							
7. Causes me to forget about my everyday concerns.							
8. Makes me ignore everything around me.							
9. Gets me fully emotionally involved.							

Dimension 6: Playfulness (9 items)

Item	1	2	3	4	5	6	7
1. Gives me an overall playful experience.							
2. Leaves room for me to be spontaneous.							
3. Taps into my imagination.							
4. Makes me feel that I can be creative.							
5. Gives me the feeling that I explore things.							

6. Feels like a mystery to reveal.							
7. Gives me a feeling that I want to know what comes next.							
8. Makes me feel like I discover new things.							
9. Appeals to my curiosity.							

Dimension 7: Social Experience (8 items)

Item	1	2	3	4	5	6	7
1. Gives me the feeling that I am not on my own.							
2. Gives me a sense of social support.							
3. Makes me feel like I am socially involved.							
4. Gives me a feeling of being connected to others.							
5. Feels like a social experience.							
6. Gives me a sense of having someone to share my endeavors with.							
7. Influences me through its social aspects.							
8. Gives me a sense of being noticed for what I have achieved.							

Source: Hogberg, J., Hamari, J., & Wastlund, E. (2019). *Gameful Experience Questionnaire (GAMEFULQUEST): An instrument for measuring the perceived gamefulness of system use*. *User Modeling and User-Adapted Interaction*, 29, 619-660.