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**Investigation of the Effect of Gamified Learning on Motivation and
Success in Math Class**



Investigation of the Effect of Gamified Learning on Motivation and Success in Math Class

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Abstract:

Purpose: Educators are consistently seeking ways to enhance classroom engagement. In response to declining student achievement in mathematics, traditional teaching methods are gradually giving way to more innovative approaches such as gamified learning. Gamified learning complements conventional instruction by creating an engaging virtual and augmented reality environment in which students can actively interact with the subject matter. This study revolves around a highly significant research question: the impact of gamified learning in mathematics education on student motivation and achievement. In this domain, investigations into the latest developments in designing and testing mathematical games have been examined.

Methodology: To this end, a literature review method has been employed, and document analysis has been conducted.

Findings: The results indicate that gamified learning proves to be a promising tool for enhancing short-term motivation and student achievement.

Unique contributor to theory, policy and practice: However, further research is necessary to determine if these gains can be sustained over the course of a semester.

Keywords: *Math Education, Gamification, Motivation, Success*



1. Introduction

In recent years, the use of information and communication technologies has become a fundamental tool in all areas of society, especially in higher education. Especially 21st century educators have to adopt technological tools to provide more effective teaching in crowded classrooms. Conducting courses with technology support and adopting pedagogical approaches appropriate to these technologies play a critical role in the efficient and effective realisation of the teaching process (Adıgüzel & Yüksel, 2012). Research shows that the use of technology in learning environments increases student achievement and strengthens classroom participation (Saraçoğlu & Kocabatmaz, 2019). In addition to factors such as student achievement, learning conditions and curriculum, successful technology integration directly affects the quality of the teaching process (Marbán & Mulenga, 2019). Nowadays, it is becoming increasingly difficult to encourage students to participate in classroom discussions and activities and to motivate them to conduct research (Hitchens & Tulloch, 2018). Especially, technology integration is considered as an effective method to motivate Generation Z students (Johns, 2015). Generation Z consists of individuals who have grown up with new technologies, are familiar with these technologies and use them comfortably. Digital games and social media are vital for Generation Z students (Çakıroğlu et al., 2017). Therefore, instead of isolating Generation Z students from these environments, it may be more appropriate to utilise the pedagogical potential of these environments (Hitchens & Tulloch, 2018).

Game playing is a social-centred process that can increase motivation and promote learning for students of all levels and age groups (Tan Ai Lin et al., 2018). Therefore, game-based and gamified learning has long been recognised as an effective learning strategy in educational processes (Bristol, 2018). Gamification aims to maximise student motivation, performance, and engagement by using components other than games in learning environments (Bullón et al., 2018; Karataş, 2014; Sánchez-Martín et al., 2017). Gamified learning enables students to develop a positive attitude towards academic tasks by connecting with their centre of interest (Sánchez-Martín et al., 2017). In learning environments, components such as badges, levels and leaderboards are used as part of gamification to provide feedback (Çağlar & Kocadere, 2015).

The decline in mathematics achievement is likely influenced by a combination of factors, including both student motivation and a lack of innovation in mathematics instruction. While motivation plays a significant role in a student's learning and success, it is not the sole determinant of mathematical achievement. The manner in which mathematics is taught and the learning environment also play a crucial role in shaping students' attitudes toward the subject. The belief in making mathematics learning engaging underscores a clear need for improvements in how mathematics is presented and taught. It can be stated that addressing both student motivation and the need for innovation in mathematics education is essential to reverse the decline in mathematics achievement. Educators can promote a more positive learning experience that motivates students to succeed in mathematics by combining engaging and innovative teaching methods. Additionally,

efforts to enhance students' intrinsic motivation for mathematics can contribute to elevated levels of mathematical proficiency. Iwamoto et al. (2017) stated that learning environments that are fun and include high student participation are important; because they stated that such environments positively affect academic success. In fun and interactive learning activities, students can be more motivated and have different learning experiences (Yapıcı & Karakoyun, 2017).

In our country, educational environments are observed to be gradually shifting towards more engaging and interactive approaches, although they may not be entirely sufficient, aiming to move away from traditional teaching methods. Educators inevitably need to make careful evaluations to strike a balance between the advantages and costs of implementing innovations. Investing in changes and research is crucial to ensure that the chosen innovations truly benefit both educators and students, leading to more efficient and effective mathematics education.

Educators who embrace gamified learning as a potential innovative approach can harness the power of technology to create a dynamic and effective mathematics learning environment. Teachers who can benefit from high-level technologies in their educational activities are very important for the success of the technology integration process (Gürsoy & Göksun, 2019). Technology plays a central role in gamified learning. Leveraging technology-enabled gamified learning will empower educators to enrich the mathematics instruction and content within the classroom. Innovative approaches amalgamate educational content with game elements, thus cultivating an engaging and interactive learning environment for students.

Gamified learning applications can offer various challenges, rewards, and interactive elements that capture students' attention and motivation. This approach is significant in that it also allows for personalized learning experiences tailored to individual student needs and learning styles. As a result, it can be said that gamified learning has the potential to enhance student engagement, increase motivation, and improve overall mathematical competence. Gamified teaching allows students to see their knowledge level and at the same time optimize their learning processes.

Recent research indicates that gamified learning represents a combination of gamification principles and traditional classroom education, offering a promising approach to enhance students' learning capabilities. This educational method typically combines a student-centered learning experience with technology in various forms. Integrating gamification components into education and training processes has been an effective strategy to increase students' interest and motivation towards lessons (Tetik & Korkmaz, 2018). These tools can also improve the learning environment by providing students with an active learning experience (Wang, 2015). The meta-analysis study on gamification conducted by Saleem et al. (2021) evaluated gamification as a useful learning tool that can be used to create more attractive learning environments.

It is important to note that the success of gamified learning is not only dependent on the game itself but also on the quality of the instructional content and other technologies used in the classroom. While our research may not delve deeply into the implementation of high-quality instructional

content or other technologies, it can be stated that the effectiveness of gamified learning in enhancing success and motivation relies on the presence of excellent teaching. Educators, by embracing gamified learning and utilizing instructional methods, can unlock the full potential of this approach and create a more engaging and effective learning experience for their students. The synergy between gamification and high-quality instruction is crucial in achieving positive outcomes in terms of student achievement and motivation.

Rewards and leaderboards are among the most common elements used in gamified learning. These elements play a significant role in increasing student participation and motivation. Educators can effectively leverage these components to tap into students' intrinsic motivation, encourage them to take an active role in their learning journeys, and create a positive, collaborative learning environment.

Since gamification does not only mean the use of components specific to game-based learning in educational environments, certain criteria should be taken into account in course design (Şahin & Samur, 2017). Game mechanics, game dynamics and game aesthetics are important criteria to be considered in gamified learning processes (Tetik & Korkmaz, 2018). Game mechanics include components such as scoring, leveling up and difficulty, while game dynamics include elements such as rewarding, gaining status and achieving success (Yapıcı & Karakoyun, 2017). Components such as scoreboards and badge system support the creation of a competitive environment as well as giving students the opportunity to evaluate their own performance (Gökkaya, 2014). Integrating gamification components into educational processes can be effective in increasing students' interest and motivation in the course process (Tetik & Korkmaz, 2018).

Rewards function as visual representations of the achievements or milestones students earn as they progress in their learning journeys. Whether big or small, earning rewards that acknowledge and celebrate their accomplishments instills a sense of achievement, encouraging students to strive for further success and fostering a positive learning atmosphere.

Leaderboards, on the other hand, typically showcase the progress and achievements of a selected group of top-performing participant students in a competitive manner. They introduce a competitive aspect to the learning process, motivating students to improve their performance and strive to be among the most successful. Leaderboards can also encourage healthy competition and promote social learning through collaboration. By observing their peers' achievements, students are motivated to learn from each other, develop a sense of community and collaboration within the class, and seek support from one another.

2. Method

Academic studies gain scientific depth and originality through appropriately conducted literature review. Almost all aspects of technology, tools, systems, ideas, and trends emerge through thorough literature review, being the outcome of scientific endeavors. In the study, one of the quantitative research methods, the literature review method, is preferred, which involves analyzing

information obtained from previously conducted studies on a specific subject, reviewing its key points, and summarizing them. This method relies on original books, theses, and articles published in international academic journals as primary sources. Referred to as literature review in research, this process encompasses activities related to exploring, locating, examining, reading, categorizing, summarizing, and synthesizing works previously published on the research topic.

3. Findings

The findings of this study are consistent with and build on previous research in the field of gamified learning, particularly in mathematics education. The extensive literature review and document analysis revealed consistent patterns highlighting the positive impact of gamified learning on student motivation and achievement in the short term. These findings are consistent with the existing body of knowledge which suggests that gamified approaches contribute to increased engagement and positive learning experiences.

A key agreement with previous research is the effectiveness of reward-based gamified learning. The inclusion of elements such as points, badges, leaderboards, virtual currency, and unlockable content in gamified systems is consistent with the motivational benefits outlined in previous studies (Çağlar & Kocadere, 2015; Yapıcı & Karakoyun, 2017). Similarly, the observation that reward-based gamification fosters a more interactive, enjoyable and motivating learning environment is in line with the literature that emphasises the positive impact of rewards on student engagement (Sánchez-Martín vd., 2017). Furthermore, the study is consistent with the idea that gamified learning in mathematics can harness advanced technologies, such as augmented reality, to create immersive and interactive experiences (Bristol, 2018). The emphasis on harnessing these technologies is in line with the wider trend in educational research, which recognises the potential of advanced tools to improve learning outcomes (Wang, 2015). Our findings highlight the evolving landscape of gamified learning, emphasising its adaptability to incorporate cutting-edge technologies for more effective mathematics education.

3.1. Gamified Learning

In its broadest sense, gamified learning refers to the incorporation of game elements into non-game subjects within lessons to enhance students' learning experiences. The fundamental premise behind gamification in education is to provide an immersive experience similar to playing games, motivating and inspiring students to continue learning. For instance, augmented reality (AR) games that involve a combination of three-dimensional, real-world, and virtual elements can facilitate more lasting learning experiences.

Games incorporating reward-based elements such as points and prizes generate primary motivation known as extrinsic motivation. Extrinsic motivation represents the drive to engage in an activity or behavior to obtain external rewards or avoid penalties. In the context of gamified learning, students are motivated to participate in and progress through the game to earn points or rewards that serve as external incentives for their efforts. Extrinsic motivation can be a powerful tool in

gamified learning as it provides tangible and immediate rewards for students' achievements. By offering points or rewards, educators can encourage students to complete tasks, achieve goals, and actively participate in the learning process.

However, striking a balance between extrinsic and intrinsic motivation is crucial. While rewards can initially enhance commitment and engagement, relying too heavily on external incentives might lead students to focus solely on winning rewards rather than immersing themselves in the actual learning experience. To create a more meaningful and sustainable impact, educators should also foster intrinsic motivation by emphasizing the joy derived from the learning process, the relevance of the content, and the development of skills and knowledge for personal growth and achievement.

Landers (2014) proposed a gamification theory based on two explicit propositions, "Instructional content influences learning outcomes and behaviors" and "Behaviors/attitudes influence learning," in order to provide guidance for both researchers and educators in designing games. The theory suggests that gamification mediates between behaviors or attitudes and learning outcomes.

Gamification can indeed serve as a mediator between instructional content and learning outcomes by creating a highly engaging learning environment. When students immerse themselves in a gamified experience, they tend to invest more time interacting with the material and remain motivated to actively participate in the learning process. By offering elements like rewards, leaderboards, points, and other game-like features, gamification captures students' attention and sustains their interest in the subject. As a result, there is a higher likelihood of dedicating extra time and effort to explore and comprehend the instructional content.

The mediating feature of gamification between instructional content and learning outcomes is an effective educational strategy. Educators can harness the power of gamification to create a dynamic and captivating learning environment that not only enhances students' understanding but also cultivates a positive attitude towards learning. By doing so, educators can tap into the potential of gamification to not only improve comprehension but also foster an optimistic approach to the learning process.

3.2. Reward-based gamified learning

Reward-based gamified learning, a strategy that integrates game elements such as points, badges, leaderboards and other rewards into educational contexts, aims to increase student motivation and engagement. In order to scientifically substantiate these findings, a thorough literature review was carried out, looking at studies focusing on gamification in education. Various research articles from reputable academic journals, including 'Educational Technology Research and Development' and 'Computers & Education', were consulted to identify key findings.

Reward-based gamified learning is a strategy that involves integrating game elements, such as points, badges, leaderboards, and other rewards, into a non-game context to enhance motivation

and engagement. In the context of education, reward-based gamification aims to make learning more interactive, enjoyable, and motivating by adding game-like features. In this approach, students earn rewards or recognition for reaching specific milestones, completing tasks, demonstrating mastery in skills, or actively participating in the learning process. These rewards can be both intrinsic (personal satisfaction, a sense of achievement) and extrinsic (points, badges, competition rankings). Elements of reward-based gamification include:

Points: Students accumulate points as they progress in learning activities or achieve specific goals. These points can signify progress and achievement, motivating students to continue engaging with the material.

Badges: Badges represent accomplishments or milestones in the learning journey. They provide a visual representation of achievements and can instill a sense of pride and accomplishment.

Leaderboards: Leaderboards display participants' rankings based on their performance or achievements. They introduce a competitive element and encourage students to strive for higher positions on the leaderboard.

Virtual Currency: Some gamified systems use virtual currency that students can earn and spend within the learning environment. This currency can be used to unlock additional content, access special privileges, or personalize avatars.

Unlockable Content: Students can earn rewards that unlock additional content, levels, or challenges, motivating them to continue interacting with the material to access new learning opportunities.

Challenges and Tasks: Gamified learning can include challenges or tasks that students can complete for rewards. These challenges can vary in complexity and difficulty.

Reward-based gamification draws on motivational and achievement principles found in games to encourage active participation and learning. By aiding students in focusing, tracking their progress, and celebrating their achievements, it can make the learning experience more interactive and enjoyable. However, using reward-based gamification carefully is important to avoid overemphasizing external rewards and undermining the true value of learning. When effectively implemented, reward-based gamification can create a positive learning environment that balances motivation with genuine interest in the subject.

3.3. Gamified Learning in Mathematics

Mobile technologies have introduced different approaches to learning, such as immersing learners in contextual learning environments using the inherent sensors of mobile devices (Tangney et al., 2010). In addition, mobile phones have been used to record mathematical learning (Project Tomorrow, 2011) and learners have been connected through mobile phones and social media (Roberts and Butcher, 2009). Crompton and Burke's (2015) review of mobile learning in

mathematics indicates a growing interest in the effectiveness of mobile technology, with 75% of 48 studies reporting positive learning outcomes. Similarly, Fabian et al.'s (2016) review of mobile learning studies in mathematics found that 77% of 31 studies reported improvements in student achievement due to mobile technology.

Pollara and Broussard (2011) highlighted that the majority of mobile learning studies reported positive student perceptions of mobile use in the classroom, a trend that is also reflected in studies of mobile learning in mathematics. Students generally found the use of mobile technologies engaging and useful (Baya'a and Daher, 2009; Lai et al., 2012). Baya'a and Daher found that students found mobile technologies useful in mathematics because they facilitated visualisation, encouraged collaborative learning, and allowed exploration of mathematics in outdoor environments. Despite positive perceptions of the use of mobile technologies, research on how these attitudes affect students' overall attitudes towards mathematics is limited and sometimes produces contrasting results.

Mobile technology offers a distinct advantage over traditional computing in supporting learners in a variety of contexts (Tangney et al., 2010). The pervasive learning environments facilitated by mobile technologies provide learners with the opportunity to engage in situational learning (Baya'a and Daher, 2009). Within these learning environments, students have discovered the usefulness of mobile devices in enhancing the visualisation of mathematical concepts. However, it's worth noting that the majority of these studies have been exploratory and qualitative in nature. Few studies have provided conclusive evidence of improvements in student performance (Wu et al., 2006; Hwang et al., 2015).

The gamified approach to mathematics education seeks to make the learning process enjoyable and engaging for students by incorporating mathematical concepts in a fun and interactive manner. Researchers actively explore ways to integrate mathematical concepts into mobile and computer games, aiming to leverage the motivational benefits that such entertainment can provide. Furthermore, they aim to facilitate and standardize the implementation of gamified learning in mathematics classes by exploring various approaches to gamification.

Researchers striving for effective gamified learning experiences continue to investigate different versions of gamified models. These models aim to strike a balance between the engaging nature of games and the effective communication of learning objectives, thereby establishing equilibrium between educational content and game elements. Through ongoing research and development, gamified learning experiences are being optimized to become more accessible, effective, and aligned with educational goals. In light of this information, here are explanations of some gamified learning models:

Competitive Gamified Learning: This model incorporates competitive elements into the mathematics learning process. Students engage in challenges, short quizzes, or tasks to outperform their peers. Leaderboards and rewards are common in this approach, as they showcase students'

progress and achievements relative to others. This method can enhance motivation by appealing to students' desire for superiority and recognition. However, it's important to balance this approach with a healthy sense of competition and inclusivity to avoid feelings of exclusion or motivation loss.

Adaptive Gamified Learning: This model tailors the mathematics learning experience to individual student needs and abilities. Through data analysis and technology, the system adjusts difficulty and content based on each student's performance and progress. This approach ensures that students receive personalized challenges and support, preventing them from getting bored by overly simple materials or frustrated by overly difficult ones. Unlike traditional learning, which may not cater to every student's pace or style, adaptive gamified learning addresses this limitation by dynamically adjusting the content and ensuring that each student is appropriately challenged. This approach increases engagement and facilitates deeper understanding of the material.

Collaborative Gamified Learning: This model emphasizes teamwork and collaboration. Students work together to solve problems, achieve goals, or complete challenges. Collaborative elements may include group projects, shared achievements, and collective rewards. This approach enhances students' communication skills, teamwork abilities, and sense of community. While collaboration may exist in a traditional learning environment, it might not be structured or an integral part of the learning process. Collaborative gamified learning actively promotes collaboration and interdependence, develops social skills, and enables students to learn from each other's strengths and perspectives.

In summary, competitive, adaptive, and collaborative gamified learning approaches offer unique advantages compared to traditional learning environments. While gamified learning can enhance motivation, personalization, and collaboration, it's crucial to carefully design and implement these strategies to maintain a positive and inclusive learning environment while effectively supporting learning outcomes.

3.4. Leveraging the Power of Augmented Reality and Advanced Technologies in Mathematics Gamified Learning

By harnessing the power of augmented reality and other advanced technologies, gamified learning in mathematics is becoming even more captivating, motivating, and effective in creating immersive and interactive learning experiences. These technological advancements enable educators to create innovative learning experiences that bring mathematical concepts to life, enhancing students' understanding and engagement.

Augmented Reality (AR) allows students to experience a blended learning environment where computer-generated elements are overlaid onto the real world. In the context of mathematics education, this means that graphical representations, tables, and other visual aids for mathematical concepts can be displayed in a more engaging and interactive manner. AR enables students to visualize mathematical concepts in three dimensions and dynamically, making abstract ideas more

concrete and comprehensible. For instance, students can explore geometric shapes within a real-world context, manipulate virtual objects, and directly interact with mathematical models using AR technology.

Furthermore, augmented reality can provide real-time feedback and assistance to students while solving math problems or working on mathematical challenges. AR can offer support by providing additional explanations, visual aids, or step-by-step guidance, enhancing the learning process. This interactive and immediate feedback loop can help students build their problem-solving skills and deepen their understanding of mathematical concepts.

By integrating augmented reality and other advanced technologies into gamified learning, educators can create a more engaging and effective learning environment. Students can actively participate in their learning journey, visualize complex concepts, and receive personalized assistance when needed. As technology continues to evolve, the potential for enhancing math education through immersive and interactive experiences is only expanding.

In their study, Sirakaya (2022) aimed to determine the reasons why teachers are interested in Augmented Reality (AR) technology. AR is a technology that enriches real-world images with virtual objects in real-time. AR is used in education across all levels, from preschool to graduate studies. The research results indicated that teachers' interest in AR is mainly driven by educational benefits, such as more effective lesson delivery, capturing students' attention, enriching lesson content, facilitating better understanding of topics, and enabling enhanced learning.

In a study conducted by Rebollo et al. (2022) regarding the impact of gamified learning through AR on student learning in mathematics, they developed two interactive mobile games to assist students in learning multiplication tables. The study included 37 students aged between eight and nine. The control group practiced multiplication tables using traditional methods, while the experimental group practiced by playing the games. The results supported the effectiveness of the mobile games developed for the study in helping students learn multiplication tables. This AR-based application provided a more engaging atmosphere for learning multiplication tables compared to traditional methods.

Shi et al. (2022), in a departure from other gamified models, created a Game-based Immersive Virtual Reality Learning Environment (GIVRLE) designed to facilitate the learning of quadratic functions. In this application, students could navigate within a virtual reality environment by wearing a VR headset. In a game called "The Crazy Pot," students used earphones to play a game where they had to break pots with projectile launchers, requiring an understanding of the properties of quadratic functions. The core idea here was to model the parabolic motion of the projectile. Furthermore, students needed to use the positions of the pots and an incomplete quadratic equation to break the pots with rocks, with the quadratic equations becoming progressively more difficult as students progressed through four levels. Through the feedback system of GIVRLE, if students answered a problem incorrectly three times in a row, they received a hint by being assigned an

auxiliary task, leading them to an instructional animation screen to guide them through the process. Finally, if students completed all levels, they could ride a bird to shoot balloons with a bow and arrow.

These studies highlight the diverse ways in which augmented and virtual reality technologies, along with gamified learning approaches, are being used to enhance educational experiences and engage students in a variety of subjects, including mathematics.

Shi et al. (2022) aimed to encourage educators to create such applications and emphasized the positive impact of gamified learning on student learning and achievement. It should also be highlighted that the costs associated with VR headsets should not be overlooked.

One of the undeniable strengths of gamification in mathematics education is its ability to allow students to visualize abstract concepts. This is evident in the work by Ottmar et al. (2015) with their application "From Here to There!" (FH2T). The focus of this study was based on the results of two main research questions. Firstly, whether students who played FH2T showed greater improvement in their final test scores compared to traditionally taught students? Secondly, whether increased exposure to FH2T predicts enhanced performance and learning? In other words, does a student's progress in the game translate to their final test score?

Elvira et al. (2023) developed a web platform named "GAMIT," aiming to evaluate changes in attitudes towards mathematics among high school students using a gamified methodology that incorporates a reward system. This platform was developed by professors from two Latin American universities to manage gamification while preserving the authenticity of class rankings. The study used a mixed (QUAN-Qual) and quasi-experimental methodology, involving 454 high school students who completed two surveys, and a focus group was conducted with a group of seven professors. The results showed benefits for both professors and students. While students improved their attitudes toward mathematics, reduced anxiety, and enhanced their willingness to learn, professors found dynamic and optimal ways to manage gamification in GAMIT. The researchers addressed questions such as "How did the reward-based gamification methodology affect high school students' attitudes toward mathematics?" and "What is the relationship between the dimensions of attention, participation, and resilience for both students and professors using a reward-based gamification methodology?" Based on the results of this study, a reward-focused gamification approach has the potential to positively impact high school students' attitudes toward mathematics, particularly in terms of reducing anxiety and increasing enjoyment. The inclusion of gamification practices to alleviate student anxiety during the learning process could significantly contribute to their overall learning experiences and potentially influence career choices. Interestingly, students perceived a positive relationship between reward-based gamification and dimensions like attention and participation, while educators saw students as more enthusiastic due to a noticeable increase in proactive engagement in activities to earn rewards. The study highlighted how educators recognized that the reward mechanism encouraged inclusivity by

acknowledging various aspects such as cognition, behavior, skills, and values. Ultimately, the findings of this study demonstrate that gamification utilizing a reward mechanism through a dynamic platform (GAMIT) positively influences the learning environment in high school mathematics classrooms. However, it's important to note that further research is needed to explore its impact on actual learning outcomes. Additionally, the researchers suggest that this gamification methodology could potentially be applied to different subjects and education levels and be aligned with effective teaching practices. Recognizing that gamification might be most suitable for educators focused on improving teaching approaches is also important.

Çin (2022) conducted a thesis study to determine the impact of gamification-based education on students' academic achievement, motivation, and entrepreneurial skills in the teaching of the topic "Operations with Fractions" in the 6th grade of middle school. The participants of the research consisted of a total of 48 students, with 25 in the experimental group and 23 in the control group, selected through unbiased assignment from a state middle school in Şehitkamil district of Gaziantep province during the 2021-2022 academic year.

Quantitative data were collected using an academic achievement test, motivation scale, and entrepreneurship scale. Qualitative data were collected using a semi-structured interview form to support the quantitative data. The academic achievement test, motivation scale, and entrepreneurship scale were administered to both the experimental and control groups at the beginning and end of the implementation as pre-test and post-test. A follow-up test was conducted 8 weeks after the completion of the implementation. The experimental group received gamification-based instruction for 4 weeks, with 5 class hours per week. The control group, on the other hand, received instruction based on traditional presentation strategies.

The results of the thesis study revealed that the majority of students had positive views on gamification applications used in mathematics classes, considering them both enjoyable and instructive. They expressed positive opinions about earning points, being on the leaderboard, and reinforcing what they learned through gamified applications. The enjoyment derived from playing games translated into enjoyment in the classroom. Notably, students who were initially biased against mathematics mentioned that mathematics became their favorite subject due to these games. Students also mentioned that time in the class passed quickly. However, they also mentioned facing some challenges and stress in time-limited games. The competitive environment excited them to some extent.

Based on these findings, it can be stated that students generally appreciated the use of gamification throughout the teaching process and found it effective in creating an enjoyable learning environment. These results are consistent with previous studies that have positive views on gamification (Asıgıgan, 2019; Aydın, 2021; Karamert, 2019; Türkmen, 2017) and provide support for the positive opinions about gamification within the scope of the research.

4. Results and Discussion

The growing number of gamers worldwide suggests a growing potential for innovative learning methods (Simoes and Vilas, 2012). Researchers have explored the compelling nature of games, attributing their appeal to a mix of fantasy, challenge, curiosity and immersive interest that keeps players engaged (Kirriemuir and McFarlane, 2004). Jane McGonigal argues that games can serve purposes beyond entertainment, claiming that the skills developed through gaming can be valuable in tackling real-world problems (McGonigal, 2011). Zichermann and Cunningham (2011) support this idea, emphasising how such processes increase user engagement and interest in problem solving.

Gamification, with its various conceptions, involves incorporating design elements from games into non-game contexts to motivate and enhance user activity (Deterding et al., 2011). It can be seen as a concept that uses game mechanics, aesthetics and game thinking to engage, motivate, stimulate learning and solve problems (Kapp et al., 2014).

Gamification is a process of integrating game dynamics and mechanics into platforms such as websites, business services, online communities, portals or marketing campaigns to encourage participation and engagement (Bunchball, 2010). Game mechanics encompass a wide range of mechanisms, actions, behaviours and controls that are used to add 'gamified' elements to activities. These mechanics aim to create an engaging and motivating experience for users. Meanwhile, game dynamics represent the needs and desires generated by game mechanics, often sought by users for pleasure and self-motivation. There are six game mechanics and game dynamics: points, levels, challenges, virtual goods, leaderboards, gifts & charity; and reward, status, achievement, self-expression, competition and altruism (Bunchball, 2010).

After a thorough examination of the studies investigating how gamified learning affects motivation and achievement in mathematics classes, we can conclude that gamified learning has the potential to enhance student achievement. However, the extent of its impact varies depending on factors such as the design of gamification, the context of implementation, and the characteristics of the participating students. It should be noted that gamified learning does not provide an infallible solution to the challenges of motivation and achievement that students face. It's important to acknowledge that educators should exercise caution when attempting to generalize the findings to all classroom environments.

Our research did not provide any evidence suggesting that gamification negatively affected student achievement in mathematics classes. We observed that highly motivated students who were already engaged in gamified activities might experience a decrease in their motivation afterward. It's worth mentioning that, although some results indicate a positive impact on both motivation and achievement in the short term, the lack of long-term studies introduces uncertainty about the lasting effects of gamification in educational settings. While gamified learning holds promise, its effectiveness depends on understanding the intricacies of its limitations and the specific conditions of its application.

However, it's important to recognize that gamified learning is not an infallible solution to the motivational and achievement challenges students encounter. Educators should exercise caution when attempting to generalize findings to all classroom environments.

Our research did not provide any evidence suggesting that gamification negatively affected student achievement in mathematics classes. We observed that highly motivated students who were already engaged in gamified activities might experience a decrease in their motivation afterward. It's worth mentioning that, although some results indicate a positive impact on both motivation and achievement in the short term, the lack of long-term studies introduces uncertainty about the lasting effects of gamification in educational settings. While gamified learning holds promise, its effectiveness depends on understanding the intricacies of its limitations and the specific conditions of its application.

The research teams comprising the studies we examined have been observed to create unique games that students play during the experiment, which often last for days or even weeks. The common aspect of these studies is their investigation of the impact of gamifying mathematics education on student achievement and motivation. These studies span the entire duration of a regular academic term. The analysis of changes between pre-test and post-test scores is used to determine student achievement outcomes. Furthermore, the research focused on motivation is based on various data collection methods, including student self-report surveys and teacher observation reports.

Researchers interested in student achievement analyze in-app data, whereas those exploring the impact of gamified learning on motivation rely on student survey results. Application data revealed that some students showed significant interest in the games, which positively influenced their motivation levels. As the time spent in the applications increased, it was observed that students in the non-gamified group solved fewer problems over time, while in the gamified groups, an increase in in-game time was associated with solving more questions.

Additionally, despite experiencing mental fatigue from solving more problems, students in the gamified group remained motivated and even increased their motivation levels over the course of the application. This indicates that although they engaged in more problem-solving activities as time passed, their motivation remained steady or even improved compared to the non-gamified group.

Gamified learning can capture students' attention and sustain their interest, leading to increased interaction with the content. This active engagement often translates to better understanding and retention of the material. Gamified systems frequently provide instant feedback, enabling students to learn from their mistakes and make immediate corrections. This feedback loop promotes a deeper understanding of concepts and helps students progress more efficiently. Many gamified systems can adjust the difficulty of content based on individual performance. This adaptive

approach can prevent boredom by offering appropriately challenging material, contributing to better achievement.

Gamified learning often involves repeated application and reinforcement of concepts through interactive activities and challenges. This can lead to better mastery of skills and improved performance in assessments. Gamified learning environments can incorporate collaborative elements that encourage peer interaction and collaborative problem-solving. This collaborative learning approach can deepen understanding and contribute to achievement. Gamified learning environments establish positive relationships with learning, encouraging students to engage willingly and consistently with the material.

While these points suggest that gamified learning can positively impact achievement, it's important to note that the effectiveness of gamification can vary. Proper design, alignment with learning objectives, and consideration of students' preferences and needs are crucial for success. Additionally, gamified learning is just one approach among many effective teaching methods. Its potential for enhancing achievement should be seen in the context of broader educational strategies that cater to diverse learning styles and needs.

If educators consider integrating gamified learning into their classrooms, we believe that a cautious approach is essential to provide an optimal learning experience. Firstly, educators should possess a solid knowledge base about common themes and mechanics present in various games. This knowledge will aid in selecting the most suitable combination of elements that align with specific classroom dynamics. Additionally, educators should seek out games that offer comprehensive summary statistics, facilitate effective assessment, and enable tracking of student progress. While superficial elements like rewards, leaderboards, and avatars can have a significant impact on certain age groups, such as elementary and middle school students, their importance may diminish as students grow older.

However, the results obtained suggest that mechanics like touchscreen interaction, adaptive algorithms, and visualizations maintain interest levels as students progress in their educational journey. Therefore, educators should focus on these mechanisms to sustain engagement.

As a result, in the studies reviewed, researchers also presented results showing that the gamified group outperformed the traditional education group. Throughout these studies, no evidence was found to suggest that gamified learning had an irredeemably negative impact on students' retention or achievement. Even holding all other factors equal, there appears to be little or no downside to the adoption of gamified learning, suggesting that there may be an opportunity cost to incorporating games into the learning process. For example, games can be strategically integrated during regular class breaks when classes are traditionally interrupted, thus minimising disruptions to the curriculum. This approach could help alleviate concerns about time allocation and facilitate the maximisation of the educational benefits of gamified learning.

For researchers interested in the topic, considering the following recommendations can contribute to understanding the effectiveness of gamified learning in mathematics education and its potential impact on student engagement, motivation, and achievement:

Define Clear Objectives: Clearly define the research objectives and questions you intend to address. This will provide a focused direction for your study and ensure that your research objectives align with the intended educational outcomes.

Select Appropriate Games: Choose games that align with specific mathematical concepts you plan to teach. Ensure that the selected games effectively integrate gamification elements and are suitable for the targeted age group and learning objectives.

Consider Learning Styles: Take into account different learning styles and preferences in your study. Different students may respond differently to gamified learning, so consider how the chosen games cater to various learning methods.

Design Effective Assessment Measures: Develop appropriate assessment methods that measure both short-term engagement and long-term learning outcomes. This could involve pre- and post-tests, observations, surveys, and qualitative data collection to comprehensively capture the impact of gamified learning.

Utilize Mixed Methods Approach: Combine quantitative and qualitative methodologies to gain a comprehensive understanding of the effects of gamified learning. While quantitative data can provide statistical insights, qualitative data can offer deeper insights into students' experiences and perceptions.

Conduct Longitudinal Studies: Consider conducting research that tracks student progress and engagement over an extended period. This can provide insights into the sustainability and long-term impact of gamified learning on student motivation and achievement.

Explore Customization and Personalization: Investigate the role of customization and personalization in gamified learning. How can games be adapted to individual student needs and preferences to enhance engagement and learning outcomes?

Teacher Involvement: Examine the role of teachers in the gamified learning process. Research how teachers can effectively integrate gamification elements into their lessons, provide guidance, and facilitate content-related discussions.

Ethical Considerations: Address potential ethical concerns, such as competition-induced stress, equity in technology access, and balancing intrinsic and extrinsic motivation. Discuss these concerns in your research and propose potential mitigations.

Inclusive Design: Pay attention to creating inclusive and accessible gamified learning experiences for a diverse range of students, including those with different abilities and backgrounds.

Collaborative Elements: Explore the impact of collaborative gamified activities. Investigate how collaboration-based tasks within games can enhance not only content understanding but also teamwork and communication skills.

Feedback Mechanisms: Examine the role of feedback mechanisms in gamified learning. How can instant feedback enhance learning and motivate students to progress?

By considering these recommendations, researchers can contribute to a better understanding of the effectiveness and potential benefits of gamified learning in mathematics education, as well as its impact on student engagement, motivation, and achievement.

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