The Improvement of Primary School Mathematics Academic Performance through Gamification Elements in Teaching Mode

Yifan Zhang*

College of Mathematics and Statistics Huaiyin Normal University, Huai'an, China

Abstract. Against the backdrop of deepening reforms in basic education, improving primary school students' interest in and achievement in mathematics has become a key research topic. Traditional mathematics teaching methods, with their abstract content and monotonous format, can easily instill fear in younger students, dampen their enthusiasm, and negatively impact learning outcomes. Introducing gamification elements such as points, badges, challenges, and narratives into teaching models can stimulate student motivation and foster active participation in class. This paper, through a literature review, systematically examines the mechanisms of gamification in primary school mathematics instruction. It focuses on the impact of different gamification elements (e.g., dynamics, mechanisms, and component elements) and their combinations on mathematical achievement, and analyzes their applicability across different knowledge types, such as number and algebra, and graphs and geometry. Furthermore, this study examines individual differences in the impact of gamification on primary school mathematics achievement. This study aims to provide theoretical and practical insights for improving the design of gamification-based instruction in primary school mathematics and promote its scientific application in basic education.

1 Introduction

1.1 Research background

As current reforms in basic education continue to deepen, how to effectively enhance students' learning interest and academic performance, especially in mathematics, a subject with a high degree of abstraction and logic, has become a key issue of concern to both educational researchers and frontline teachers. As a foundational subject, mathematics plays an irreplaceable role in cultivating students' logical thinking, problem-solving skills, and scientific literacy. However, traditional elementary school mathematics instruction often leads some students to develop a fear of difficulty, a lack of enthusiasm for learning, and even "math anxiety," due to factors such as abstract learning content, monotonous teaching

* Corresponding author: zhangyifan@ldy.edu.rs

methods, and repetitive after-class exercises. This can seriously impact their academic performance and long-term development.

1.2 Research gaps

In the current field of education, although research on the application of gamified teaching models in primary school mathematics has made some progress, there are still many research gaps that need to be filled.

First, there's insufficient research on the effectiveness mechanisms of gamification elements. Most current studies have only gone so far as to confirm the effectiveness of gamification in instruction, but lack in-depth exploration of the specific roles of different gamification elements in improving academic performance. For example, clear and systematic conclusions haven't yet been reached on which gamification elements are most effective in consolidating knowledge points or developing students' logical thinking skills.

Secondly, the application of gamification elements is too one-sided. Existing research mostly focuses on the impact of a single or a few game elements (such as using only badges or leaderboards) on mathematics performance, and lacks systematic research on the combination of multiple gamification elements.

Finally, current research rarely examines the impact of students' individual differences (such as gender, learning style, and cognitive level) on their acceptance of gamification elements.

1.3 Research objectives

This study explores the core gamification elements that influence primary school mathematics academic performance. Through a literature review, this study analyzes the differences in the impact of different gamification elements on student academic performance in primary school mathematics instruction. This study identifies which gamification elements are key to improving academic performance and further explores how these core elements influence academic performance, providing a theoretical basis for the selection of gamification elements in instruction.

This paper optimizes the combination of elements and explores the differences in the learning effects of different game element combinations on different types of mathematical knowledge (numbers and algebra, graphics and geometry, statistics and probability). It also proposes a gamification element combination strategy for different mathematical content to improve the pertinence and effectiveness of gamification teaching in teaching different mathematical content.

2 Identification and mechanism analysis of gamification elements in primary school mathematics teaching

2.1 Definition of gamification

Regarding the definition and connotation of gamified learning, Li Yanrong believes that gamified learning is when teachers integrate the thinking and mechanism of games into the teaching of specific subjects. In the entire teaching activity, students learn knowledge through gamification, and the role of teachers' changes to that of guides and helpers of teaching [1]. In non-game situations, teachers purposefully apply gamification design elements (such as points, badges, leaderboards, levels, challenges, narratives, instant feedback, etc.) and game

principles (such as goal setting, clear rules, progressive challenges, and reward mechanisms) to guide behavior, enhance motivation, and increase participation.

2.2 Theoretical basis of gamified education application

The theoretical basis of gamification education application is mainly rooted in cognitive development theory, learning motivation theory and flow theory. Cognitive development theory advocates that the individual's cognitive structure is constantly improved with the growth of age and experience [2]. Primary school mathematics is an important stage for cultivating students' logical thinking and abstract thinking ability. Teachers' classroom teaching needs to closely follow the students' cognitive development laws. Gamification teaching is based on this theory. By designing challenging and interactive games, abstract mathematical theories are integrated into specific life situations, so that students can gradually deepen their understanding of mathematical knowledge through hands-on operation and personal experience in the game. Learning motivation theory: Learning motivation theory emphasizes that students' learning motivation is the key factor affecting their learning behavior and effect. Traditional teaching methods often focus on the inculcation of knowledge and only pay attention to whether students understand the knowledge, but ignore the stimulation of students' learning motivation [2]. Flow theory: Well-designed gamification tasks can enable students to enter a highly focused and immersed "flow" state through clear goals, immediate feedback and challenges that match their skill levels [3]. This is a highly engaged and pleasant psychological state, which is the key to achieving effective gamification learning. A well -designed gamification system can strike a balance between learning challenges and knowledge skills, helping learners enter a flow state.

2.3 The impact of gamification elements on mathematics learning

Primary school students are in a stage where their attention is not easily focused and concrete thinking is dominant. Boring knowledge explanations and mechanical exercises often fail to stimulate their interest in learning, resulting in low learning efficiency and slow improvement in academic performance. Gamified teaching can transform mathematical calculations into interesting games by creating interesting role-playing situations, thereby arousing students' interest and involvement. For example, a teacher can design a role-playing game in which students play the roles of shopkeepers and customers and perform simple mathematical calculations during transactions [4].

After participating in gamified learning, students' performance in mathematics has improved significantly. This improvement is not only reflected in single test scores but also in the depth of understanding of subject knowledge and the enhancement of application ability. In the gamified learning environment, students continuously improve their problem-solving skills through tasks and challenges, and thus perform better in subject exams [5]. It can be seen that compared with traditional teaching, the teaching model that systematically integrates multiple gamified elements (such as points + badges + challenges + instant feedback) can significantly improve the scores of primary school students in standardized mathematics tests or unit tests.

2.4 Classification and definition of gamification elements

Gamification elements can generally be divided into three categories: dynamic elements, mechanical elements and component elements. They are designed to motivate users to participate and change their behaviour [6]. In primary school mathematics teaching, these

elements are often used flexibly to create a more attractive and effective learning environment.

2.5 The promotion effect of different gamification elements on different cognitive levels

Mechanism-based elements such as points and badges can add motivation and fun to students' learning, effectively stimulating their enthusiasm for learning [7]. By setting up various ways to earn points and badges in classroom teaching, students' learning enthusiasm can be aroused, making them more proactive in participating in learning and strengthening their memory of basic knowledge points.

Dynamic elements such as narrative and situational simulation can make abstract mathematical knowledge more concrete, allowing students to understand and apply knowledge more easily in familiar or interesting scenarios [7].

Component elements such as tasks and achievements effectively encourage students to transfer the knowledge they have learned to solving practical problems and improve their application capabilities.

2.6 Analysis of the impact mechanism of core gamification elements on mathematics academic performance

Gamified teaching enhances students' learning motivation through goal setting and reward mechanisms, breaks down complex knowledge into step-by-step game tasks, reduces cognitive burden, and enhances students' emotional engagement through role-playing, cooperative competition, and other methods, thereby promoting deep learning. An empirical study conducted by an educational research institute showed that in a mathematics learning environment that adopts gamification elements, students are more focused and their learning motivation is significantly enhanced, resulting in better mathematics learning results [8].

3 Differences in the effects of different combinations of gamification elements on mathematics teaching effectiveness

3.1 Classification of primary school mathematics knowledge types and analysis of gamification demand

The primary school mathematics knowledge system is guided by core literacy and is divided into the following four areas: numbers and algebra, graphics and geometry, statistics and probability, and integration and practice [9]. For the different types of mathematical knowledge mentioned above, the focus of gamification requirements is different. Numbers and algebra emphasize logic and accuracy, and are suitable for level-breaking and competitive games to stimulate reaction speed and strengthen calculation ability; graphics and geometry require spatial perception, and can develop spatial imagination through AR modeling, puzzle operations, etc.; statistics and probability focus on data thinking, and it is advisable to use interactive forms such as simulation experiments to exercise thinking ability; integration and practice emphasize application and collaboration capabilities, and can promote communication and integration capabilities through project-based games such as role-playing.

3.2 Design of a diversified combination of gamification elements

Cooperation (team tasks) + competition (rankings, points): Integrating challenging and competitive game activities into primary school mathematics classes, and then cleverly incorporating cooperation elements to construct a team competition teaching environment can significantly improve their mathematical thinking ability [10].

Narrative (story, role) + achievement (badge): Embed a mathematical knowledge system into a continuous story scenario. After students complete the corresponding questions, they will obtain corresponding badges and achievements.

3.3 Analysis of the effects of different element combinations on the learning of various mathematical knowledge

In the first gamification combination, collaborative elements (such as working as a group to solve a complex math project) foster communication, collaboration, and problem-solving skills, while healthy competition (such as a leaderboard between groups) fosters a competitive spirit and motivates students to work harder.

Complete story scenarios provide meaning and context for learning. Earning badges and titles (such as "Geometry Master" and "Data Detective") not only serves as a reward but also signifies learning progress, demonstrating students' growth in mathematics and encouraging them to invest more time in learning new mathematical knowledge. For example, students embark on an adventure in a virtual world, having to solve various mathematical problems to advance the story. Successfully solving a specific type of problem will earn them a badge representing the corresponding skill.

4 Individual differences in the impact of gamified instruction on primary school mathematics academic performance

4.1 Research on the impact of gamified teaching on deep learning effectiveness and its correlation with academic performance

Some case studies of long-term implementation of gamified teaching have found that students' academic performance in mathematics has significantly improved after participating in gamified learning. This improvement is not only reflected in single test scores, but also in the improvement of their deep understanding of subject knowledge and application ability. Students continuously improve their problem-solving ability through tasks and challenges in the gamified learning environment, and thus perform better in subject exams [8]. Gamified teaching helps students improve their calculation ability, strengthen their understanding of the essence of mathematical concepts, and cultivate logical thinking and problem-solving skills by integrating game elements (such as challenges, rewards, immediate feedback, and situational narratives) into the mathematics learning process.

Furthermore, gamified instruction is significantly positively correlated with academic achievement. Improved deep learning outcomes are directly reflected in students' superior performance in complex problem-solving, open-ended tasks, and knowledge comprehension. While standardized test scores may be influenced by multiple factors, gamified instructional strategies indirectly support sustainable academic achievement growth by promoting learning persistence, positive attitudes, and strategic flexibility.

4.2 Analysis of the impact of gamified teaching on students with different knowledge levels and academic foundations

Gamified instruction has varying effects on students with different levels of prior knowledge. For students with weaker foundations, the immediate feedback and low-stakes challenge environment of gamification can reduce their fear of failure, encouraging them to try again and again, thereby consolidating their foundational knowledge and skills. However, for high-achieving students, if gamified tasks lack sufficient challenge and depth, they may become bored and perceive gamification elements as a distraction, a waste of their time, and ultimately prevent them from reaching their full potential.

4.3 The impact of gamification elements on learning outcomes for different genders

Boys show a greater interest in competitive and challenging games, which stimulate their enthusiasm for problem-solving. Girls, on the other hand, prefer games with strong action elements and rich storylines, which help them learn mathematical concepts in a relaxed and enjoyable atmosphere. For example, in math class, boys may be more interested in math competition games, while girls may be more engaged in math role-playing games with storylines. If gamification design favors one gender, it may inadvertently reduce the participation of the other.

5 Conclusion

This study systematically reviews the application mechanism of gamification elements in primary school mathematics teaching and their impact on academic performance. It explores the feedback of different combinations of gamification elements on mathematics teaching. Gamification elements, by stimulating students' learning motivation, have a positive promoting effect on primary school students' mathematics academic performance. Different types of gamification elements have different emphases in function. Mechanism-based elements can effectively motivate students to participate in basic training, dynamic elements help to visualize abstract knowledge, promoting understanding and transfer, while component-based elements encourage students to apply knowledge to practical problems, enhancing comprehensive abilities.

Secondly, the effectiveness of gamification in teaching not only depends on the characteristics of the gamification elements themselves but also relies on their compatibility with teaching content and the way they are combined. For different knowledge types such as numbers and algebra, geometry and graphics, statistics and probability, teachers should adopt differentiated strategies for combining gamification elements. For instance, a combination of competition and cooperation is suitable for numbers and algebra, while a combination of narrative and achievement is more appropriate for geometry and graphics, which require contextual support.

Furthermore, there are significant individual differences in the effectiveness of gamification teaching. Students' prior knowledge levels, gender, learning styles, and other factors all influence their acceptance and participation in gamification elements. Therefore, future gamification teaching designs should be further optimized, paying more attention to individual differences among students. This study explored the mechanisms and combination strategies of gamification elements from a theoretical perspective, but it still has certain limitations, such as the lack of large-scale empirical data support and the inability to deeply explore the differential responses of students in different grades and regions. Future research can further conduct empirical investigations, combining quantitative and qualitative methods

to verify the effectiveness of different gamification combinations in actual teaching, and explore the design of personalized gamification learning paths based on artificial intelligence to promote the scientific and precise development of gamification-based teaching in elementary mathematics education.

As a promising teaching innovation, gamification holds significant value in enhancing primary school students' interest in mathematics and improving their academic performance. Educators should understand its mechanisms and rationally select and combine gamification elements, taking into account individual student differences and the specific characteristics of the instructional content to optimize teaching outcomes.

References

1. Y. Li, Action research on gamification learning in high school information technology course teaching. SXNU (2013).
2. Y. Li, Application of gamification teaching in primary school mathematics classroom. Tianjin Educ. **13**, 177–179 (2025).
3. M. Csikszentmihalyi, Flow: The psychology of optimal experience, (Harper & Row 1990).
4. W. Gou, A brief analysis of the application of gamification teaching in primary school mathematics teaching. Bijie Daily, 2023-08-07, 003 (2023).
5. C. Shi, Research on the impact of primary school mathematics gamification learning strategies on students' mathematics interest and performance. Chengcai **11**, 97–99 (2024).
6. K. Werbach, D. Hunter, For the win: How game thinking can revolutionize your business. Wharton Digital Press (2012).
7. C. Zhang, Exploration of strategies for integrating gamification elements into primary school mathematics classes. Math. Learn. Res. **17**, 134–137 (2025).
8. Y. Qin, The impact of gamification teaching on primary school students' mathematics interest and performance. Math. Learn. Res. **27**, 152–154 (2023).
9. Ministry of Education of the People's Republic of China, Compulsory Education Mathematics Curriculum Standards (2022 Edition). BJNUP (2022).
10. X. Feng, Application of gamification teaching model in primary school mathematics classroom teaching. J. Chin. Multi. Online Teach. (Second Half) **6**, 189–192 (2025).