

Gamification in Primary School Mathematics Education

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Abstract. The use of gamification in primary mathematics education remains one of the critical topics of research today. Researchers have found that gamification plays a positive role in teaching and learning the relevant curriculum and can be used in different areas. However, there is a lack of specific research on using gamification in various components of primary mathematics education. Few researchers have made suggestions for rationalizing gamification in mathematics education. Therefore, this article examines the topic of gamification in primary school mathematics education. The paper analyses the challenges faced by the gamification process and makes recommendations. It has been found that gamification can stimulate students' interest in learning, enhance their motivation, help them consolidate and understand relevant knowledge, and bring about good learning outcomes. Gamification can also help students to construct appropriate geometric structures and contribute to the development of creative thinking. However, the challenges of gamification include the distraction of students and difficulty in designing lessons. Teachers need to create games based on the needs of their students. As organizers, they also need to keep a tight rein on their students to prevent them from doing things that are not related to the content of the lesson. This study provides insight into the use of gamification in Mathematics in primary schools and provides a relevant basis for future research into this topic.

Keywords: Gamification, Primary school, Arithmetic, Geometry.

1. Introduction

In recent years, as education development has received increasing attention, primary education has received widespread attention as the key to laying a good foundation. Considering the difficulty and importance of the subject, maths is the most popular of all issues. In the context of the "14th Five-Year Plan", the professional development of teachers has put forward clearer requirements for teachers' ability and quality in teaching and educating people. At the same time, under the influence of the current "double reduction" policy, it is particularly important to improve the teaching mode and quality of mathematics education. Gamification is considered to be an emerging technology and is also believed to have a big impact on education in developed countries. It is also seen as a new way of bridging the generation gap between teachers and students, so that there can be better interaction between teachers and students to ensure that students understand what they are learning better. But gamification is also seen as disruptive to teaching and learning. It has also been shown that playing games in the classroom can distract students to the point where they cannot concentrate on learning.

So, what is the impact of gamification on different elements of primary mathematics education? Are they all positive impacts? Does gamified instruction help to improve the structure of teaching and enhance student achievement? Are there solutions to the problems in gamification? Exploring these questions can be very helpful in optimizing the quality of education as well as stimulating children's creativity.

This study looks at Arithmetic and Geometry in Primary Mathematics Education, focusing on the positive impacts and challenges that gamification has on these two components of teaching. The study also proposes solutions to the possible challenges.

2. Gamification in Arithmetic Education

The study of arithmetic underpins all mathematical learning and is the longest-studied element in primary education. Many students face a lot of difficulties in arithmetic, which also affects the

learning of later contents [1]. In recent years, innovative pedagogies have emerged with the constant changes in technology. Gamification has brought a lot of positive effects to numeracy education, but it also faces a lot of challenges.

2.1. The Application of Gamification in Arithmetic Education

Arithmetic education in primary schools is centered around the four operations. The four operations are an important part of primary school mathematics, specifically the mixed calculations of addition, subtraction, multiplication, and division [2]. As education continues to reform, the use of gamification in numeracy education is becoming more widespread. For example, when learning the most basic operations of addition and subtraction, the teacher can design a game about shopping [3]. The teacher prepares several items, labels them with different prices, and writes different values of money on a piece of paper. The students take different values of money to buy the teacher's goods, and the rule is that all the money must be spent exactly. As long as the students correctly calculate the sum of the prices of all the items purchased, they will win a prize. This one game helps students' understanding by incorporating arithmetic knowledge into their favorite shopping activity.

One more example of a gamified application is in teaching mixed arithmetic, teachers can use a game called "24 points" [3]. Students are divided into groups, and each group is given a set of cards containing different numbers. The rules of the game are: four cards are drawn at each turn, and the students use the rules of four operations to mix the four numbers with a final result of 24 to get a game coin. The group that gets the most game coins win the grand prize. This game then combines the knowledge related to mixed operations with a game so that students can repeat the operations over and over again while competing, thus eventually learning the arithmetic method.

These are just two examples of arithmetic specifically; there are many more applications of gamification in arithmetic, and teachers can choose games that correspond to the needs of their content.

2.2. Positive Impacts of Gamification on Arithmetic Education

Arithmetic has always been a common problem in primary mathematics education. It is difficult for primary school students to perform complex calculations effectively, and the learning process of the four operations is relatively boring, making it difficult for many students to maintain long-term interest in learning arithmetic. The emergence of gamification can effectively improve the situation. Based on prior evidence, gamification is an effective educational tool that, through a set of rules, not only increases student engagement but can also improve their understanding of mathematical concepts.

Gamification makes learning arithmetic fun in the classroom and can greatly enhance student engagement and motivation. Most students get bored with traditional pedagogy [4]. Gamification combines game elements with educational context. The game itself is entertaining. Gamification, the innovative pedagogy, can quickly attract students' attention, especially young students. Numbers are lifeless, and it is difficult for students to concentrate on learning if the teacher is the only one to narrate the content alone, so it is necessary to involve all students in exploring knowledge through games. In gamification, given that most children tend to have a strong interest in games, it is easy for them to speak and think deeply when they are in an area of interest to them, and this can greatly enhance their motivation to learn. In the card game mentioned above, students were actively involved in the game, and everyone was eager to win the rewards, which invariably motivated the students and made the children happy while learning the boring content.

Gamification makes the content easier to understand and helps students learn. Understanding mathematical content is fundamental to learning maths, and most children struggle to understand abstract mathematical algorithms, which leads to their inability to arrive at the final answer correctly. Concepts cannot be accepted by children just by explaining them; they have to be reinforced by constant practice. Gamification can combine what has been learned with the elements of a game, and as students complete the game, they can also naturally review what they have already learned, while

deepening the impression of these concepts in their brains. This can be demonstrated in the game described above, where the ever-changing deck of cards means that students need to apply the four rules of arithmetic to solve problems. In the process, students repeat these calculations over and over again, and quickly come to understand these concepts.

2.3. Challenges of Gamification in Arithmetic Education

The use of gamification in numeracy education also faces many problems. It has to be admitted that gamification can bring a lot of advantages to primary school mathematics education and can make teaching more efficient. But at the same time, it also faces many challenges.

Firstly, it is easy for students to become overly focused on the game, resulting in a lack of mindfulness to focus on the content. Many students get addicted to games that distract them, thus making them unable to focus on what they really have to master. For example, when participating in a card game, most students will follow the teacher's imperatives to complete the steps, but there will be students who will use the cards for other purposes and communicate with each other about content unrelated to arithmetic. This not only interferes with their learning but also disrupts a good learning atmosphere and distracts other students from their studies.

One other major challenge to gamification is the design of the game. For gamification, there are several crucial elements that should be known by educators, including users, challenges/tasks, points, levels, badges, and ranking of users [5]. Not all content is suitable for gamified instruction. Using gamification to teach starts with making sure that it fits with the content and that the content is not rigidly combined with gamification. If the pedagogue uses gamification inappropriately, then it may have the opposite effect. Teachers play a very important role in the game design process and need to keep designing the game according to the actual situation of the students and the relevant content.

3. Gamification in Geometry Education

Gamification plays an equally important role in teaching geometry content. Geometry in primary school mathematics involves recognizing shapes such as triangles, rectangles, squares, and circles. Students also learn how to calculate their perimeter and area. Learning this helps students develop spatial thinking and the ability to think in multiple directions. According to research, gamification can bring many benefits to geometry learning, but there are also problems that need to be solved.

3.1. The Application of Gamification in Geometry Education

Geometric shapes can help students develop a good sense of space and a rich imagination while opening up their thinking ability, so when teachers teach geometric shapes, they should allow students to exercise their own ability in the process of learning and cognition by looking at geometric shapes from different perspectives. With the continuous innovation of technology, there are more and more applications combining games and geometry.

Unlike traditional teaching, modern education allows content to be presented in a multimedia format. Teachers can use such technology to divide geometric shapes into different looks and then integrate them dynamically [6]. This process will help students to construct the shapes of different figures in their brains and help to improve their spatial imagination. In addition, teachers can use flash to create games so that students can understand the characteristics of geometric shapes more clearly. However, when using games or multimedia technology, it is important to make sure that students are involved. It is meaningless if only the teacher gives a demonstration.

Gamification can be demonstrated not only through technology, but teachers can also organize fun games for students to learn about geometry. For geometry, it is not enough to know the concepts, but practice is needed to deepen the knowledge. Teachers can let students play games in groups, through group communication and collaboration to complete the game, which is more conducive to the improvement of students' thinking ability. For example, when teaching triangles, teachers can let students divide into several groups to complete the game. Different types of triangles represent

different types of treasures distributed in various areas of the classroom. Students need to find different treasures and identify their shapes even if they get a point and the final score of the final victory. This game not only involves students in the classroom but also reinforces their knowledge of the game.

3.2. Positive Impacts of Gamification in Geometry Education

Gamification brings many benefits to geometry education. Incorporating games into learning makes the whole process more efficient and stimulates students' interest in learning. To learn geometry, teachers should develop students' logical and spatial thinking skills, and students should acquire the ability to think independently and apply their knowledge flexibly. Gamification can help to optimize the optimization of the teaching process. The teacher, through the game, creates a variety of learning atmospheres so that students have the fun to master knowledge and improve their overall quality. Games are also closer to life so that students can improve their confidence in learning, which helps to improve the efficiency of learning. In addition, the game can also stimulate students' interest in learning. Interest can produce a happy mood and also provide a positive emotional effect on learning. In the process of games, students are more active in participating and thinking about how to win, which helps to improve the quality of learning.

A very important form of teaching in gamification is cooperative teaching. In mathematics instruction, strong effects are associated with cooperative learning [7]. During the game, students will be divided into groups to work together to complete it. It means that this is an open-ended classroom of exploration. Instead of being the leader of the class, the teacher will allow students to gain knowledge by discussing and sharing their ideas with each other and guiding them through the process in a sensible discussion. In the game of triangles, students are divided into three groups and need to discuss the characteristics of triangles and how to calculate the perimeter on their own and ultimately come to win the game. Cooperative group learning can improve students' creative thinking ability so that students can express their own views in a cooperative environment, forming a multi-level and multi-angle communication mode. This learning environment enables students to give full play to their creative thinking and form different answers to the same questions, which helps students develop their own unique understanding of mathematical concepts. Therefore, gamification is a very effective pedagogical method that is worth promoting in teaching.

3.3. Challenges of Gamification in Geometry Education

Despite the many benefits that gamification can bring to geometry education, some challenges still cannot be ignored.

The first is that current classroom conditions may not support relevant games about geometry. Although technology is developing rapidly and many multimedia techniques are favorable for teaching and learning generation, they are not widespread in most schools. Instead of adopting these innovative pedagogies, many schools continue to teach in traditional ways, thus causing them to lag far behind. Without adequate financial support, education stagnates. In addition, adequate space is needed for games to be played. Many school classrooms accommodate close to 60 students, taking up almost the entire classroom, and leaving little room for games to be played. Having too many students also makes it difficult to ensure that no student can participate in the game, as it takes up too much classroom time. These are all objective environmental factors that are missing, resulting in gamification not working properly.

A further challenge is the need for teachers to improve their competence. Research has shown that playing games in the classroom can take up most of the time, so how teachers go about coordinating the time spent on games and content is particularly important. If games take up too much time, then the teacher will not have time to review and consolidate the content, and students will quickly forget what they have learned, which makes games meaningless. In addition, games played in small groups need to be more carefully managed by teachers who cannot leave students out of the game. Educators

must ensure that every student is involved in the game in order to achieve its purpose. Therefore, there is much more that teachers need to do.

4. Suggestions for the application of gamification in Primary School Mathematics Education

The above studies show that although gamification is very beneficial to primary mathematics education, there are still many challenges that need to be addressed. Therefore, this study will focus on exploring improvements in gamified classrooms, including optimizing instructional design, diversifying academic assessment, and developing teachers' teaching and classroom management skills.

4.1. Optimize Instructional Design

The purpose of optimizing instructional design is to make teaching and learning more efficient. Many people think that children's poor academic performance is related to their own inattention or inattentiveness, but in fact, the rational design of classroom teaching content is more helpful for students to master knowledge efficiently [8]. Educators should focus on how to design the teaching content to make students learn more solidly and how to make the classroom more efficient.

Contextual design can be optimized first. Context is an important means of promoting students' active learning and is also the starting point for activity-based and inquiry-based learning, and a good context can better stimulate students' innovative thinking [9]. Contexts should be created with authenticity, and games that are close to life will make students feel more familiar and will help the activities to be carried out. Games that are related to the real world are more conducive to stimulating students' creativity and have more practical meaning and value. For example, the shopping game mentioned above. This is something that every student likes to do, and students are familiar with the process, which also keeps the classroom organized. Context creation also needs to be challenging; games that are too easy do not fully engage students, and games that are too difficult can leave students without solutions. The design of the game situation must be based on the teaching content at the same time, the difficulty of the slight increase so as to fully stimulate the students' thinking ability.

The design of the play materials is just as important as the design of the questions [9]. During the game, the teacher asks different questions so that the students can think about the knowledge while participating in the game. The questions must be open-ended and progressive. The difficulty of the questions must be deeper and deeper as the game progresses so as to help students cultivate innovative thinking. The design of the game materials is also very important. The purpose of the whole game is to provide students with experience, and rich materials are more helpful to achieve this purpose. Rich materials can also provide students with more room for creativity. For example, the treasure hunt game mentioned above. Different types of triangles can be made into different treasures to increase the fun of the game, simulate the most realistic game scenarios, and provide students with a richer experience.

4.2. Diversified Academic Assessment

Diversified pedagogical assessment is equally important for gamified teaching and learning. The traditional way of assessing students stops at the final exam. This has led to many parents focusing on the final exam and ignoring the students' excellent performance in the classroom. Therefore, a comprehensive assessment of teaching and learning is necessary.

Diversified pedagogical assessment is equally important for gamified teaching and learning. The traditional way of assessing students stops at the final exam. This has led to many parents focusing on the final exam and ignoring the students' excellent performance in the classroom. Therefore, a comprehensive assessment of teaching and learning is necessary. Teaching evaluation should also comprehensively assess the learning process and learning outcomes of students. Student-led assessment should also be added to allow students to reflect on their own performance [10]. In this

study, students participate in the assessment process by adopting a multiple assessment method that combines teacher assessment, student self-assessment, and student mutual assessment.

The implementation of formative assessment and monitoring of the teaching process is useful for comprehensive teaching evaluation. Formative assessment includes a comprehensive assessment of students' preparation before class, learning in class, and learning behavior after class. Pre-lesson preparation includes checking and assessing students' content preview in the first ten minutes of class. Learning in class includes observing students' participation and performance in the game. For example, in a scavenger hunt, the student who finds the most treasure and calculates the perimeter correctly should receive the highest score. Considering that the games are played in small groups, peer assessment can provide a better picture of each student's performance in the game. The self-assessment session allows students to reflect on their own performance so that they can make better progress. For gamified education, grading should not only be based on examination results but students should be praised for their talents and innovations shown in the games.

4.3. Develop Teachers' Teaching and Classroom Management Skills

Although the gamified curriculum is student-led, it cannot be separated from the careful guidance of the teacher. The core reason why many schools are unable to implement gamified education is that teachers do not possess the relevant teaching skills and management abilities. Therefore, it is necessary to enhance teachers' competence in primary mathematics education and their ability to organize games well.

Gamification teaching does not mean that the whole classroom is all about games. Teachers first instill and impart the necessary knowledge to answer the students' doubts about what they have learned. The game is played after the students have initially understood all that they have learned. First of all, teachers need to know the interests of every student so that they can design a game that is suitable for the whole class. It is not possible to just copy previous games. Teachers also need to develop their creative skills, and being able to innovate games on the basis of the content is more conducive to increasing student participation. Secondly, teachers need to conduct continuous game simulations to ensure that students fully understand the content and rules of the game. If the game cannot be played properly in the classroom, then the content taught will not be absorbed by the students. Teachers must also have good coordination skills. Teachers need to guide students through the game efficiently and control the length of the game so that it does not interfere with the learning of the content [11]. Some students may not be able to fully engage in the game, so teachers need to manage those who don't follow the instructions to ensure that every student is able to participate and learn.

5. Conclusion

This study found that gamification is significantly helpful for primary mathematics education, but attention still needs to be paid to the problems that need to be addressed. Unlike many studies that worry that gamification cannot be integrated into the classroom, gamification does bring many benefits to primary school mathematics learning. First of all, whether for arithmetic or geometry, gamification can stimulate students' interest in learning, increase students' participation, and can effectively improve students' learning performance. Secondly, gamification help students understand mathematical concepts, and on this basis, it can cultivate students' innovative thinking and their ability to think in various aspects. The multimedia era also provides more choices for gamification courses. This study provides a comprehensive account of the use of gamification in primary mathematics education. Not only does it present the benefits of gamification to the curriculum, but it also highlights the challenges and problems that need to be addressed, and unlike previous studies, it also focuses on solutions to the problems, such as optimizing classroom design, improving teachers' pedagogical and organizational skills, and diversifying academic assessment. All these provide theoretical and factual references for the future popularization of gamification. Primary mathematics education is

fundamental, so it is necessary to carry out innovative reforms in the classroom, which will be helpful to students' learning in the future.

Considering that gamification is not completely widespread, this article is still limited in terms of its impact and solutions. In addition, this study focused on arithmetic and geometry in primary maths education and was not designed for the other components, which is an area for continued research in the future. Gamification has an impact on every element of primary mathematics education to a greater or lesser extent, so in the future, when gamification becomes more popular, research can be further refined or expanded in new directions on the relevant variables mentioned above in order to facilitate in-depth research on the topic.

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