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Gamification Teaching in Mathematics Subject as A Guide for Future Teaching and Learning

Yiling Liu, Fazilah Razali

Faculty of Educational Studies, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia

Email: fazilahrazali@upm.edu.my

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Abstract

The study aimed to determine the practical application of gamification in real-life mathematics classrooms in lower primary schools in China and students' satisfaction with gamification in mathematics classrooms. A total of 141 students from the lower grades (grades 1-3) of Chinese public primary schools participated in the survey and quantitative data were collected through the Student Evaluation of Educational Quality (SEEQ) form. Eight areas were assessed using the five-point Likert-type scale: (1) Learning (2) Enthusiasm (3) Organisation (4) Interaction (5) Breadth of Coverage (6) Examinations/ Grading (7) Assignments (8) Workload/Difficulty. The relationship between gender and interest in learning mathematics was analyzed using a t-test. The results of the study show that students are more satisfied with gamified teaching and that gender affects the interest in mathematics learning (in favor of males). In conclusion, gamified teaching is better used in practice in the mathematics classroom of lower grades in Chinese public primary schools, with higher levels of student satisfaction.

Keywords: Gamification of Teaching and Learning, Primary School Mathematics, Interest in Learning, Student Satisfaction, Seeq

Introduction

In recent years, gamified teaching has been increasingly applied to education, promoting learning and encouraging students to actively participate in learning activities to improve students' motivation to learn and help them expand their knowledge (Lo & Hew, 2020). The most general definition of gamification is “the use of game design elements in non-game contexts” (Zsoldos-Marchis, 2020). In several contexts, the gamification concept and its operationalization in non-gaming contexts have become a growing practice (Patrício et al., 2020; Sebastian Deterding & José Zagal, 2018). However, Koivisto et al. (2019) show that gamification research is still in its early stages.

Mathematics education is a discipline that studies the practice of and approaches to teaching mathematics. Mathematics educators are highly concerned with promoting the practice of mathematics education and developing tools for its research. Mathematics education also

engenders intense debate in modern society (Yang et al., 2021). Simultaneously, the researchers point out another problem: due to the abstract and ambiguous nature of the content of mathematics learning, students often tend to lack motivation (Mutlu, 2019; Re et al., 2020). Moreover, children's attention increases with age in primary school (Zhan et al., 2022). This shows that students in the lower grades are more likely to lack classroom attention. It is worth mentioning that educational games, or game-based learning methods, have gained many researchers' attention because they are effective learning tools that engage and motivate students and, thus, improve their academic achievement (Hooshyar et al., 2018; Pontes et al., 2020; Zumbach et al., 2020). Gamification is based on the theory of self-determination (SDT). The SDT theory defines the external and internal factors and their interrelationships that motivate people to take action, whereby external factors can be rewards or punishments, and internal factors are fun or curiosity (Ünlü, 2023). Susan et al. (2021) pointed out that early math achievement has an interactive effect on attitudes towards mathematics, and whether students have a positive attitude towards mathematics learning affects mathematics academic performance. In addition, there is a gender difference in students' attitudes towards mathematics (preference for boys), which already appears in early to middle primary school.

Thus, using gamification can lead to a more spontaneous willingness to join in the classroom, a more active desire to solve problems, and more practical application in learning because the tasks become interesting and varied. In terms of strengths, students found that gamification motivated them to participate, and students found lessons with gamified elements more interesting and engaging than those without gamification (Zsoldos-Marchis, 2020). Additionally, research on gamified instruction reflects positive effects on children's cognition, skills, social-emotional competence, and attitudes (Fadhli et al., 2020).

As Marchis Iuliana (2020) observed, some researchers concentrated only on acquiring points through any means, while gamification is more about developing extrinsic motivation. Therefore, it is important to determine whether students are satisfied with the gamification teaching methods used in teaching at this stage. Only by authentically collecting students' satisfaction with the current actual teaching can we effectively adjust teachers' future teaching strategies based on the feedback of this information.

A considerable wealth of gamification-related literature (Sun et al., 2023a) discusses how and when to introduce gamification into the classroom and the benefits of using gamification for teaching and student learning. Notably, in recent years, the use of gamified teaching practices has been described at various educational stages. Furthermore, more researchers have analyzed its effectiveness in primary education, unlike most of the similar proposals that have focussed on other stages, such as secondary education (Alsadoon et al., 2022; Alt, 2023; Lavoué et al., 2021), or on the teaching of higher education (Aldalur & Perez, 2023; García-Álvarez & Serradell-López, 2022; Hammill et al., 2021; Sobrino-Duque et al., 2022; Wang et al., 2021).

In contrast, in the past decade, the practical application of gamification teaching in mathematics has accounted for a small proportion of the total disciplines, and most researchers pay more attention to the connection between gamification teaching and science disciplines (Sun et al., 2023b). For students' responses to gamified teaching, a limited number of researchers use the Student Evaluation of Educational Quality (SEEQ) for feedback analysis. Furthermore, most of the feedback information collection occurs after the specified course and gamification teaching experiment, which makes it difficult to describe the actual application of gamified teaching during students' daily learning activities.

The overarching research questions guiding the present study were:

a) To determine how satisfied younger elementary school students are with gamified instruction.
b) To determine the practical application results of gamified teaching in China lower grade mathematics classrooms.

Method

Research Location

The selection of the location of this study uses a purposive sampling strategy. The reason why Xi'an City was chosen is because Shaanxi Province is one of the more representative provinces in Northwest China, followed by Xi'an City. As the capital of Shaanxi Province, Xi'an City is not only the most populous city in Shaanxi Province (Statistics Bureau of Shaanxi Province, China, 2023), but it is also the city with the most schools in Shaanxi Province (Statistical Bulletin on the Development of Education in Shaanxi Province, China, 2022). The reason for choosing a public primary school as the research object is that the public primary school can strictly adhere to the curriculum standards in implementing China's education policy, which is a strong typicality of the Chinese education targeted by the study. Based on references to studies with similar characteristics, we randomly selected 141 students in three grades (grades 1 to 3, about six to 10 years old) to obtain results. The questionnaire was distributed via Google Forms. A simple random sampling method was used to give students in grades one through three the opportunity to answer a research questionnaire. Furthermore, before the students filled out the questionnaire, all selected participants were told that they were free to withdraw at any time and that they could decide for themselves whether or not to participate in the survey. Therefore, the study's results can be generalized to the research field.

Research Design

To listen to students as fully as possible, the survey was designed to conduct a random sample of students from grades one through three within the school while following the Student Evaluation of Educational Quality (SEEQ) model (Marsh, 1984). This adaptation consists of 18 questions grouped into eight dimensions:

1. Learning
2. Enthusiasm
3. Organization
4. Interaction
5. Breadth of Coverage
6. Examinations/Grading
7. Assignments
8. Workload/Difficulty

The survey was subjected to a reliability test using Cronbach's α internal consistency coefficient (Cronbach, 1951). It is applied to the set of factors proposed to measure different characteristics of the same concept. Its process as a single component touches only one feature of a concept (Taan & Hajjar, 2018). The coefficient value "applicable to attitudes, opinions, questionnaires or scale reliability analysis" is generally distributed between 0 and 1 (Lei & Razali, 2021). It was found that the questionnaire presented in this study has an overall Cronbach's coefficient of 0.914, and its reliability is considered adequate, according to Barrios and Cosculluela, because it ranges between 0.7 and 0.95 (Suárez-López et al., 2023).

Instrument

Eighteen questionnaire items were equipped with a five-point Likert-type scale. A score of 1 means "strongly disagree," while a score of 5 means "strongly agree." With permission, sixteen items were adapted from María Jose Suarez-Lopeza et al.'s study (2023), and the researchers developed two items themselves. Respondents were also asked to provide demographic details, such as their age, gender, and grade.

Data Collection and Analysis

Since gamification teaching has been widely used in the mathematics classroom teaching of this public primary school, and to ensure that the data collected is more relevant to students' daily lives, these data will not be collected after a specified course content or time, instead will be collected during a random moment in the semester (during the one semester of 23/24). Considering the ability of younger students to understand the questionnaire's content, the questions in the Google Forms were only explained by the teacher to the students and did not influence their thinking. The data was calculated using a manual scoring method and entered into Google Forms. A preliminary data analysis was performed using descriptive analysis and a t-test using SPSS.

Table 1 and Figure 1 show the sample, including the number and age distribution of students completing the satisfaction survey from grades one to three in the first semester of the 2023-2024 academic year.

Table 1
samples of students who completed the questionnaire.

			Gender		
			Female	Male	Total
Grade	1	Count	23	23	46
		%within Grade	50.0%	50.0%	
	2	Count	26	24	50
		%within Grade	52.0%	48.0%	
	3	Count	23	22	45
		%within Grade	51.1%	48.9%	
Total		Count	72	69	141
		%within Grade	51.1%	48.9%	

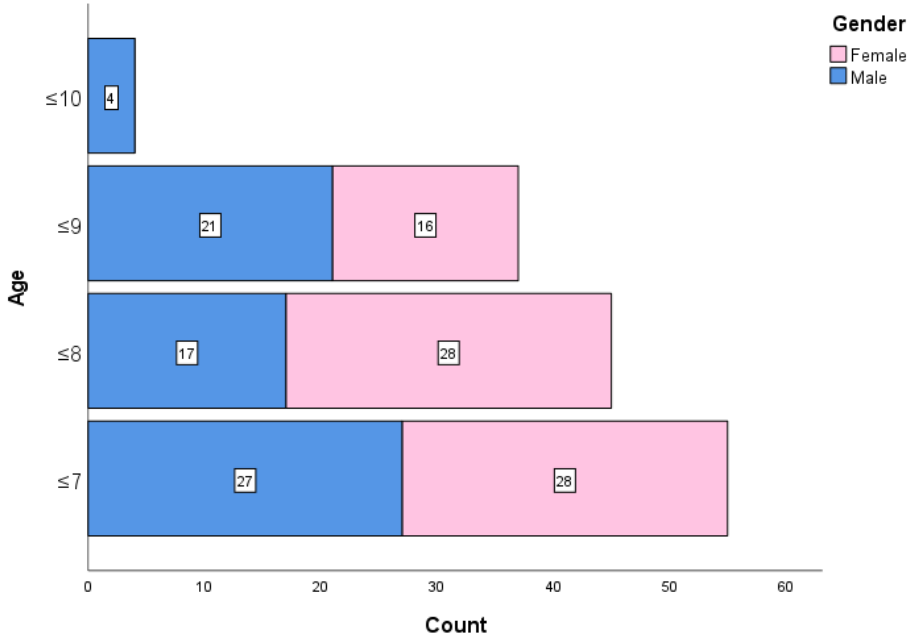

Figure **1**: Age distribution of students who participated in the study and completed the questionnaire.

Table 2 shows the results of the descriptive analyses: number of valid cases, mean, median, mode, standard deviation, and variance. Regarding the eight survey categories, the mean score for each category was higher than 3 (average), except for the "Difficulty of this activity compared to others", which had a mean score of 2.62. This suggests that students are optimistic about gamification's practical application and effectiveness in their day-to-day teaching and learning in the mathematics classroom. This assessment is supported by the "LEARNING" category results, where both the mode and median scores are greater than or equal to 4. The students are very satisfied with the participation, organization, interactions, breadth of coverage, grading, and assignments (mode score 5). In addition, the use of gamification in the mathematics classroom increased students' interest in the subject (mode and median at both 5). Similarly, for the teachers' performance in the classroom, all received a score of 5. In the "WORKLOAD/DIFFICULTY" category, the mode of "Difficulty of this activity compared to others" was merely 1. At the same time, "Gamification takes up reasonable time in the classroom" is as high as 5, which indicates that gamification in the math classroom does not involve a higher level of difficulty and workload than other games. The acceptance of the proportion of time spent in the classroom on gamification is relatively high. Therefore, it can be seen that students' acceptance of gamification in the daily mathematics classroom is high, and teachers' schedule for gamification is more reasonable.

Table 2
Descriptive Analysis of the Problems in the Questionnaire.

Questions	Valid	Mean	Median	Mode	Std. Deviation	Variance
Can understand what is taught during the course game.	141	4.09	5	5	1.075	1.156
This method of learning is very effective.	141	4.26	4	5	0.875	0.766
I am interested in studying mathematics.	141	4.03	4	5	1.189	1.413
Satisfaction during classroom games.	141	4.24	5	5	1.034	1.07
From the beginning, I had an accurate understanding of the content of the classroom game activities.	141	4.12	4	5	0.952	0.907
I can easily find textbook materials for classroom play activities.	141	4.33	5	5	0.922	0.85
Classroom games helped me better understand the class content.	141	4.14	4	5	0.975	0.951
This activity increased my interest in learning the subject.	141	4.21	5	5	0.999	0.997
The teacher was very helpful in answering our questions.	141	4.35	5	5	0.933	0.871
The teacher has accepted the student's initiative.	141	4.38	5	5	1.012	1.024
This activity has helped me to acquire additional knowledge.	141	4.09	5	5	1.204	1.45
The results achieved in classroom games are fair and appropriate.	141	4.14	4	5	1.004	1.008
I find the demonstration in classroom games useful for understanding classroom knowledge.	141	4.27	5	5	0.985	0.97
With this activity, I have been able to learn more than simply having a class.	141	4.02	4	5	1.204	1.45
The difficulty of this activity compared to others.	141	2.62	3	1	1.402	1.965

Gamification takes up reasonable time in the classroom.	141	3.98	4	5	1.111	1.235

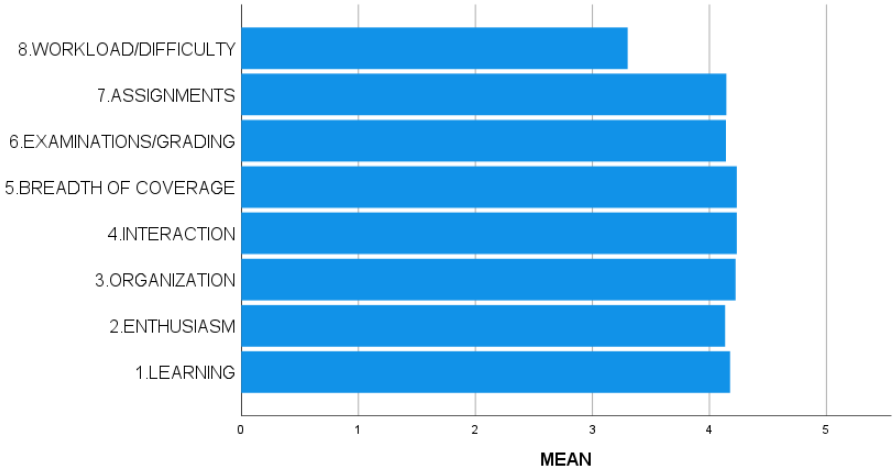

Figure **2**: Average values by category.

Figure 2 shows the mean values for each category. The students' mean ratings for each category ranged from 3 (agree) to 5 (strongly agree). The maximum value corresponds to the categories INTERACTION and BREADTH OF COVERAGE (4.23), and the minimum value corresponds to the WORKLOAD/DIFFICULTY categories (3.30).

The following are specific analyses of student responses to questions under each category in the satisfaction survey (Fig. 3). For the questions listed, the chart presents the percentage of students and the corresponding satisfaction ratings standard on the scale: Strongly Disagree (1), Disagree (2), Generally (3), Agree (4), Strongly Agree (5). Details of the percentages chosen by the students are provided below.

In the "Learning" category, 19.9% of students showed that they understand moderately what is taught during the course gamification process, but 70.3% were quite satisfied and extremely satisfied (4+5). Regarding the effectiveness of gamification, the percentage of students who were satisfied and strongly satisfied (4+5) was as high as 83%, while an equal proportion of students felt that the practical aspects of the gamification process helped them to understand the course content. Seventy-three percent of students showed a strong interest in learning mathematics (4+5), and only 16 students showed a lower interest in learning mathematics. The data shows that 79.4% of all students indicated satisfaction and strong satisfaction (4+5) with the games in the mathematics classroom. The organization of the activities demonstrated that 76.6% (4+5) of the students knew exactly what the activities of the classroom games were about from the beginning, and 80.1% (4+5) were able to easily find the textbook content corresponding to the content of the games. The interactive part of the classroom was evaluated very positively: more than 75% (4+5) of the students felt that the classroom games helped them to better understand the class content. Gamification increased the interest of more than 80% (4+5) of the students in learning about mathematics, and almost the same percentage of students thought that the teacher was very helpful in answering questions. The highest level of satisfaction was found in the students' comments about whether the teacher was receptive to the participation of all students, with close to

85% of the students being very satisfied (4+5). However, only 73.8% (4+5) of the pupils felt that the maths games helped them to learn something other than maths.

Around 93.6% of the respondents (3+4+5) stated that the outcomes achieved during classroom games are fair and appropriate. Fewer than 20 students felt that including maths games also made them feel like they had a lesson (1+2).

However, close to 30% (4+5) of the students found the difficulty of games in the maths classroom harder for them than other game activities in the daily application of gamification in the maths classroom. But as for the percentage of gamified instruction in mathematics classroom time, close to 90% of the students performed reasonably well (3+4+5).

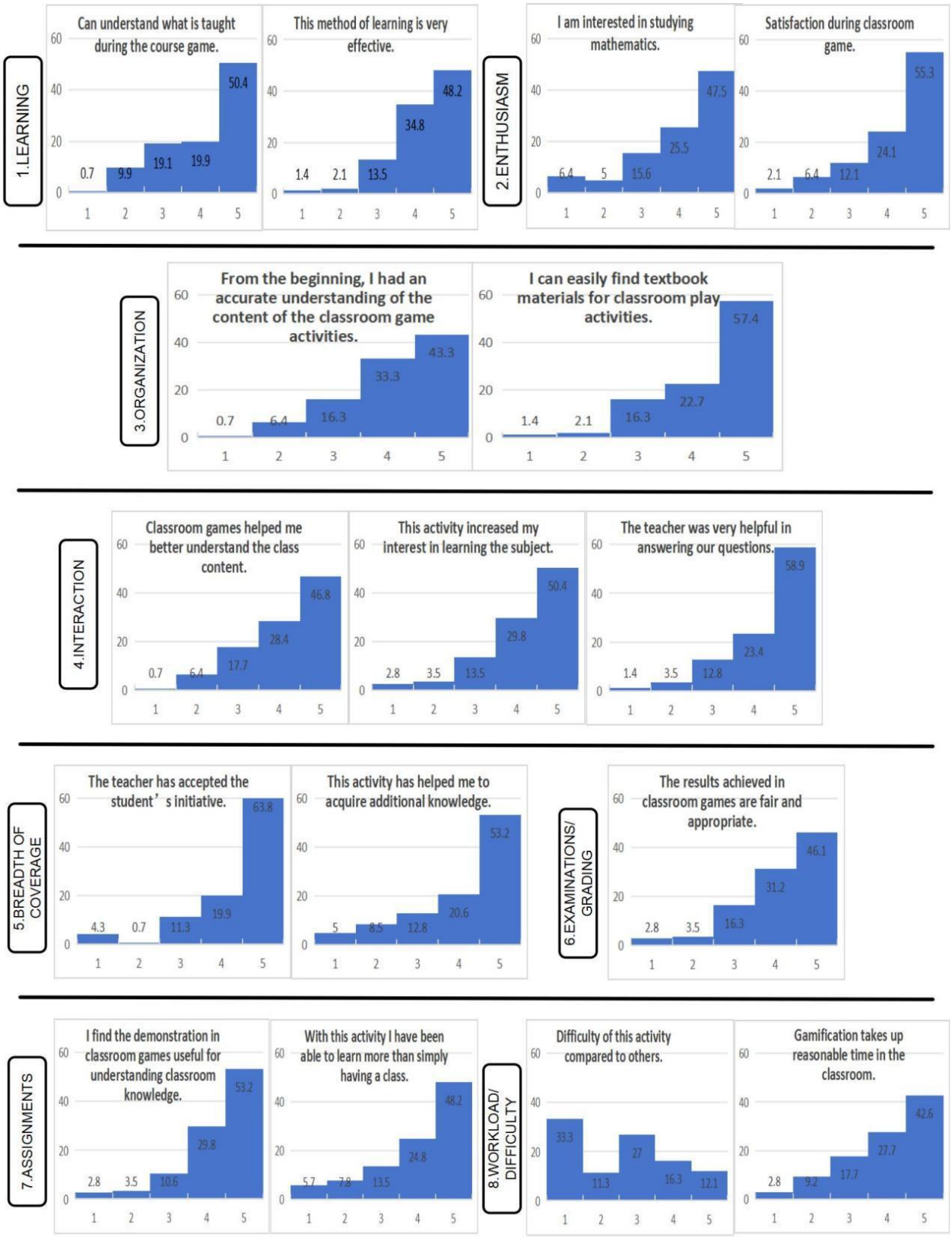

Figure **3**. Students' satisfaction in participating in the activity by categories and questions.

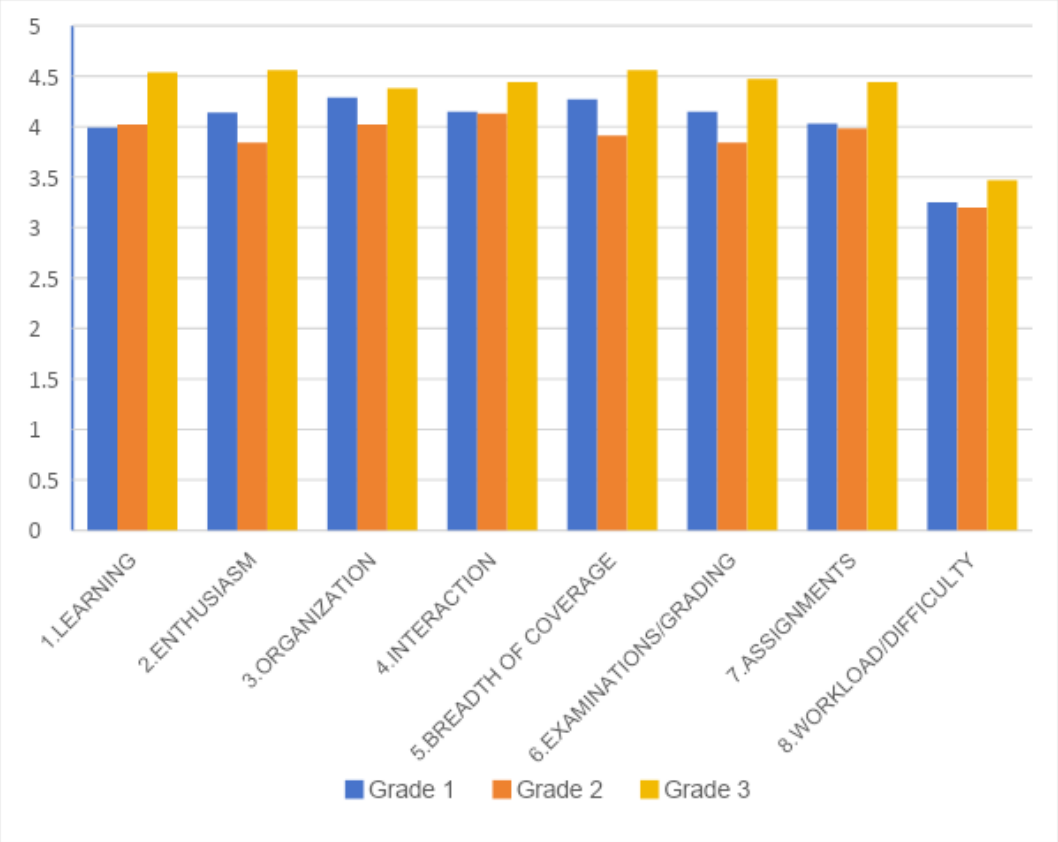

Figure **4**: Average of survey scores for different categories for three grades.

To provide a more visual representation of what is being compared, Figure 4 shows the average scores corresponding to the different questions grouped by category for the three grades in the survey. As the statistical analyses show, there were no highly significant differences between the grades. However, some individual cases of responses deserve comment.

Table 3 shows that according to the independent samples t-test, a significant difference can be found in the mean between gender and interest in learning maths ($p = 0.022$). We also considered whether gender was still relevant to the increase in interest in learning after including the gamification factor. However, the results showed that we could not find statistical significance to support the difference between the means of the two groups ($p = 0.161$).

Table 3
Student's Gender and The Degree of Satisfaction and Interest In Learning Maths.

	Gender	N	Mean	Std. Deviation	Std. Error Mean	Sig
I am interested in studying mathematics.	Female	72	3.81	1.274	0.15	0.022
	Male	69	4.26	1.052	0.127	
This activity increased my interest in learning the subject.	Female	72	4.1	1.128	0.133	0.161
	Male	69	4.33	0.834	0.1	

According to Table 4, even though the mean of ratings for interest in learning maths remained at 5 (strongly agree) for both males and females, we can still see that interest in learning maths is higher for males, a phenomenon that is already evident in the lower grades of primary school.

Table 4
Descriptive analysis of students' gender with interest in learning maths.

I am interested in studying mathematics.						
	Valid	Mean	Median	Mode	Std. Deviation	Variance
Female	72	3.81	4	5	1.274	1.624
Male	69	4.26	5	5	1.052	1.107

Discussion

In this study, we formulated and discussed the satisfaction level of students in the lower grades of Chinese public primary schools at the present stage with gamified teaching in the mathematics classroom, and determined the practical application results of gamified teaching in China's lower-grade mathematics classrooms. In the study, authentic feedback from students in eight dimensions: Learning, Enthusiasm, Organisation, Interaction, Breadth ofCoverage, Examinations/Grading, Assignments, and Workload/Difficulty were identified. These results are valuable because they provide evidence of how students feel during real daily teaching activities and help provide concrete directions for future investigations of gamified instruction and changes in teaching strategies.

According to the student's perception of whether they can understand the content delivered in the game and whether the actual practice of game-based teaching activities helps them to understand the content, it can be seen that gamification teaching can have a significant effect on students' learning of mathematics, especially by improving their mathematics performance. The results follow the findings of Hooshyar et al. (2018) that educational games are effective learning tools that engage and motivate students, thereby improving their academic performance. However, during the study, we found that in special individual cases, not only were some students disinterested in participating and learning because of the high difficulty level of mathematical gamification, but some students were not interested in gamification because they found it to be too low in difficulty, and thus lacked the experience of playing and learning. This is an issue that deserves our attention.

We also discovered from students' feedback on the effectiveness of teachers' class organization, class interaction, and fairness in the gamification process that gamified teaching can motivate student participation and that lessons with gamification elements are more interesting and engaging than those without gamification (Zsoldos-Marchis, 2020). Through the high feedback from the majority of students on whether they were able to gain additional knowledge in the classroom through math games and that the inclusion of a gamified instructional environment in the math classroom was more than just a lesson, it can be determined that gamification also positively impacts children's development in terms of cognition, skills, social-emotional competence, and attitudes (Fadhli et al., 2020).

Comparing the results of the evaluation according to the three grades for the eight categories, we can determine that there is significant effectiveness of gamification in primary education, especially in the lower grades, but we did not find any significant differences in the effectiveness of gamification depending on students' ages. However, as Susan C et al. (2021) suggested, there are gender differences in students' attitudes towards learning math, and it is clear that boys have a higher willingness to take an interest. This phenomenon occurs in the early years of primary school.

Nevertheless, there are some limitations to this study. The first limitation is geographical. As mentioned previously, this study was conducted in Xi'an, a representative city in northern China. As Xi'an is considered a developing region in northern China, we do not know whether gamification is used to teach daily mathematics subjects in more remote northern cities. We know little about the level of satisfaction of the students there. Another limitation of this study is the translation of the data. As only quantitative research surveys were used in this study, we can only know the level of student satisfaction. It was not possible to know the specific reasons for dissatisfaction in cases of low satisfaction. Even though this study focused on the lower levels of primary school, the strategies given for future instructional adjustments can also be used by teachers in the upper levels.

In addition, the results of this study provide some ideas for future adaptations of gamification activities. For example, since students' interest in mathematics learning is affected by gender and favored by males, the addition of gamification teaching factors is not related to gender for students' interest in mathematics learning. Hence, this means future studies can consider focusing on females in terms of the gamification factors of teaching and learning to make up for females' lack of interest in learning math.

Conclusion

This study examined the satisfaction level of students in the lower grades of Chinese public primary schools with gamified instruction in the mathematics classroom at this stage, demonstrating the effectiveness of gamified instruction in the lower grades of the mathematics classroom and its impact on students' learning, interest, engagement, and the development of other cognitive abilities. Specifically, gamification is beneficial in lower primary classrooms to enhance students' mathematics learning. For students, the teacher's organization, content difficulty, interactive experience, fairness, and time spent on the gamified teaching and learning process all relate to the interest and effectiveness of students' participation in the process. The results show that at this stage, students in the lower grades of China's public primary schools are more satisfied with gamified teaching in the mathematics classroom, and the practical application in China's lower-grade mathematics classrooms is more satisfactory. However, there is still scope for progress in applying gamified teaching in the mathematics classroom.

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APPENDIX

Questionnaire

Read each statement and make a selection based on your true feelings. Select the word or phrase that best describes your thinking and circle the number for your answer.

1	2	3	4	5
Strongly disagree	Disagree	Generally	Agree	Strongly agree

	Statement	***Scale***			
1	Age	□≤7	□≤8	□≤9	□≤10
2	Gender	□Female		□Male	
3	Grade	□Grade 1 □Grade 2 □Grade 3			
LEARNING					
4	Can understand what is taught during the course game.	1 2 3 4 5			
5	This method of learning is very effective.	1 2 3 4 5			
ENTHUSIASM					
6	I am interested in studying mathematics.	1 2 3 4 5			
7	Satisfaction during classroom games.	1 2 3 4 5			
ORGANISATION					
8	From the beginning, I had an accurate understanding of the content of the classroom game activities.	1 2 3 4 5			
9	I can easily find textbook materials for classroom play activities.	1 2 3 4 5			
INTERACTION					
10	Classroom games helped me better understand the class content.	1 2 3 4 5			
11	This activity increased my interest in learning the subject.	1 2 3 4 5			
12	The teacher was very helpful in answering our questions.	1 2 3 4 5			

BREADTH OF COVERAGE		
13	The teacher accepted the student's initiative.	1 2 3 4 5
14	This activity helped me acquire additional knowledge.	1 2 3 4 5
EXAMINATIONS/GRADING		
15	The results achieved in classroom games are fair and appropriate.	1 2 3 4 5
ASSIGNMENTS		
16	I find the classroom games demonstration useful for understanding classroom knowledge.	1 2 3 4 5
17	With this activity, I have been able to learn more than simply having a class.	1 2 3 4 5
WORKLOAD/DIFFICULTY		
18	Difficulty of this activity compared to others.	1 2 3 4 5
19	Gamification takes up reasonable time in the classroom.	1 2 3 4 5

Thank You For Your Cooperation