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The Effects of Gamification towards Year 5 Students' Achievement in Number Sense, Attitude and Motivation in Learning Mathematics

Santini A/P Surashkumar, Norulhuda Ismail

School of Education, Faculty of Social Sciences and Humanities, Universiti Teknologi Malaysia, Malaysia

Email: santinisurashkumar@ymail.com

Corresponding Author Email: p-norulhuda@utm.my

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Abstract

Mastering number sense is essential. However, teachers need more resources to help them teach number sense to their students. For these reasons, the objective of this study is to investigate whether gamification teaching and learning can improve the number sense performance, motivation, and attitude of students. The topic of Number Sense was investigated using a quasi-experimental research design among Mathematics year 5, with one intervention group and one control group. A pre-test was given before the treatment sessions and post-test was given after a total of eight treatment sessions to both groups where the intervention group received gamification in number sense learning. Based on the analysis of the test results, it appears that the performance of the intervention group significantly improved after receiving the treatment. After the post-test, a survey was given to both intervention and control group to investigate the attitudes and motivations of the participants in learning mathematics. After the treatment session, the intervention group's attitude and motivation differed significantly from those of the control group. It can be concluded that the use of gamification in teaching and learning can enhance students' number sense and their attitude and motivation toward learning mathematics.

Keywords: Gamification, Attitude, Motivation, Number Sense, Mathematics

Introduction

In mathematics education, number sense has emerged as a significant area in recent decades. In common parlance, "number sense" is the ability to understand and work with numbers in general, as well as the versatility to apply operations to make sound mathematical decisions (Maghfirah & Mahmudi, 2018). Number sense is the developed capacity of an individual, derived from early exposure to mathematical education. The process begins with the identification of numbers and their representation in a meaningful manner, in order to comprehend the operation and significance of their use in daily life. This capability can be effectively developed if the acquired knowledge and skills are derived from a meaningful educational encounter.

In order for students to be able to solve problems in a creative, analytical, and flexible manner, they need to have significant number sense ability (Butuner, 2017). Number sense requires thinking that is rational, creative, effective, and flexible. It will be challenging to overcome hurdles in mathematics learning due to a lack of comprehension of number sense. Although the term "number sense" is not commonly used in Malaysian mathematics education, one of the goals of the curriculum is to give students the opportunity to acquire fundamental mathematical skills such as estimation and rounding (Ministry of Education, 2004) which relates to number sense.

Many experts Mohamed & Waheed (2011); Mata et al (2012); Ngussa et al (2017) believe that students' attitudes and motivation are the most important determinants of mathematics success. Attitude is one's propensity to like or dislike something. Sarmah and Puri (2014) explain that attitudes are taught character qualities. Attitudes can change over time Syyeda (2016); Akinsola & Olowolowoye (2008), which can help students learn. On the other hand, self-beliefs and motivation determine mathematics performance (Habók et al., 2020). Mathematical achievement is linked to both internal and extrinsic motivators, as shown in many studies (Hannula, 2006; Middleton & Spanias, 1999; Singh et al., 2002) and students' motivation is the most crucial part of mathematical teaching. To put it simply, motivation is the eagerness or appeal that prompts action, sustains that behavior, and establishes one's goals. It is important to note that desire can change in both its intensity and its direction (Ryan & Deci, 2020; Slavin, 2019; Zimmerman & Schunk, 2011). However, students seem to show poor attitude and low motivation in learning mathematics.

The Malaysian Education Blueprint entails students to acquire critical thinking, creativity, communication, teamwork, and digital skills to be at par with the global development. Teachers must focus their immediate attention and effort on assisting students with fundamental mathematics operation skills in order for students to be better prepared for the challenges in education. Consequently, a simple, adaptable, and effective method should be tailored to assist teachers in achieving the objective in the normal course of their instruction and to get students to be active in class. This study endeavours to determine whether implementing a gamification-based learning strategy can improve students' mathematical performance in the areas of number sense and basic mathematical operations while increasing their motivation and attitudes towards mathematics.

Objectives

1. To determine the effect of gamification teaching and` learning on Year 5 students' performance in number sense.
2. To compare students' motivation towards learning mathematics with and without gamification.
3. To compare students' attitudes towards mathematics with and without gamification.

Literature Review

The development of number sense is required for understanding number relations and basic mathematical operations (NCTM, 2000). NCTM recognises number sense as one of its five strands of mathematical proficiency. The knowledge to which young children gain a sense of numbers and become proficient in the fundamental arithmetic operations is a strong indicator of how well those children will perform in mathematics in later years of formal education (Dyson et al., 2013). Number sense encompasses the capacity for rational, creative, effective, and flexible thinking. Consequently, pupils with strong number sense abilities are

capable of solving problems in a creative, analytical, and flexible manner (Butuner, 2017). Adequate numerical intuition is required for tackling complex mathematical issues. Sood and Mackey (2015) propose that number sense serves as the fundamental basis for pupils to comprehend formal mathematical notions. Hence, possessing a proficient number sense is crucial for kids to anticipate their future mathematical achievements.

As a consequence of this, there is a growing emphasis, all over the world, on the early development of a sense of numbers and the fundamental mathematical operations (Chen et al., 2015). Having a good grasp of numbers and being able to perform simple arithmetic operations is also stressed in An International Journal for Teaching and Learning (Parmjit, 2009). Despite the importance of identifying and helping children who struggle with mathematics (Gersten et al., 2005), many schools have not made this a top priority (Reys et al., 1999). Developing countries like Malaysia are particularly hard hit by this issue (Ghazali et al., 2004; Singh, 2009). As a consequence of this, the unsatisfactory results prediction that Malaysian schoolchildren would underperform behind the national average in mathematics achievement due to a lack of number sense and basic arithmetic operation skills Ghazali (2010) was made. This also lends credence to the notion that the mathematical ability of Malaysian schoolchildren has not significantly improved over the course of the past two decades.

Students that struggle with number sense could possibly have difficulty with fundamental mathematical operations like addition, subtraction, multiplication, and division. They could have trouble understanding mathematical principles and how they can be applied, and they might solve mathematical issues by relying on memorization rather than understanding mathematical concepts. Students may also have difficulty justifying their answers or explaining the mathematical thought behind their solutions. Moreover, individuals may have difficulty applying mathematical principles to problems that occur in the actual world. Many students rely heavily on rules because they are unable to apply flexibility in their calculations due to a lack of understanding of the comparable expressions of numbers and figures.

According to a recent study conducted by Heyder et al (2020), although their research primarily focuses on students' intrinsic motivation rather than achievement, the findings indicate that teachers who hold the belief that mathematics requires innate ability contribute to lower intrinsic motivation among low-achieving students. The findings indicate that instructors' convictions regarding the role of inherent aptitude in achieving success in mathematics could be a significant barrier to establishing a classroom environment that promotes active participation and learning for every student (Heyder et al., 2020). These findings indicate that teachers play a crucial role in influencing students' motivation to learn. So that, sstudents' low achievement in number sense and general disinterest in mathematics may have several root reasons. Students' poor performance in this area is primarily caused by a lack of willingness to learn and develop number sense abilities.

Besides that, aaccording to Mullis et al (2020), students who have a positive attitude towards mathematics are more likely to enjoy the subject, think of it as worthwhile, and feel confident when they engage in it. Furthermore, these pupils dedicate additional time and exert more effort towards the study of mathematics. However, according to Chouinard et al (2007); Guo et al (2015); Wigfield et al (2016), students who have a negative attitude towards mathematics typically despise the subject, think it is pointless, and are frightened to participate in it. Students in this category have a tendency to avoid activities that involve mathematics (Cho & Hwang, 2019). Consequently, it is reasonable to infer that there is a

direct correlation between a student's attitude towards mathematics and their level of accomplishment in mathematics. Huitt (2005) posits that when teachers lack confidence, are not imaginative with their course delivery, are unhappy with their own learning, and deal with personal problems, their pupils lose motivation.

Lee and Hammer (2011) suggest gamification teaching and learning to engage students and improve their number awareness. Previous researchers have examined the impact of gamification on the achievement and attitude of fifth-grade students in mathematics classes at a middle school. The intervention group's academic performance increased substantially more than that of the control group (Türkmen & Soybaş, 2019). According to additional study conducted by Hutson et al (2022), gamification learning has demonstrated educational benefits such as student engagement, time spent on tasks, motivation, and learning outcomes. Results from a study conducted by Yildirim (2017) found that using gamification in the classroom positively affected both students' performance and their perceptions of the value of the material being taught. The study presented here employs gamification in educational settings to bridge the gap and assist students. The effect of gamification teaching and learning on fifth-grade students' capacity to improve their performance in number sense will be investigated, and to determine the effect of students' attitude and motivation towards learning mathematics with gamification.

Conceptual Framework

Figure 1 shows the conceptual framework of the study. "Number sense" refers to the capacity to comprehend and manipulate numbers in a broad sense, as well as the flexibility to use mathematical processes in order to make informed decisions (Maghfirah & Mahmudi, 2018). According to Nickerson and Whitacre (2010), number sense is an awareness of how numbers interact with one another. This is a crucial skill that everyone must acquire in order to solve number problems in their routine lives. The three fundamentals of number sense are counting, thinking about the whole and its parts, and thinking about proportions.

One way to conceptualize motivation is as a spectrum, with intrinsic motivation residing at one end of the spectrum and extrinsic motivation occurring at the other. According to Fettahloglu and Ekici (2011), a person is more likely to be motivated by their own intrinsic interests if the activities in which they engage are ones in which they take pleasure participating. The term extrinsic motivation refers to the desire to engage in an activity for reasons other than the satisfaction of completing the activity itself. This study uses the concept of intrinsic and extrinsic motivation to determine students' motivation in learning mathematics after gamification.

Meanwhile, attitude is defined by how students behave, their emotions towards mathematics and what they think about mathematics. Based on the research conducted by Mullis et al (2020), it has been found that students who possess a positive attitude towards mathematics tend to derive enjoyment from the subject, perceive it as valuable, and feel a sense of confidence when they actively participate in it.

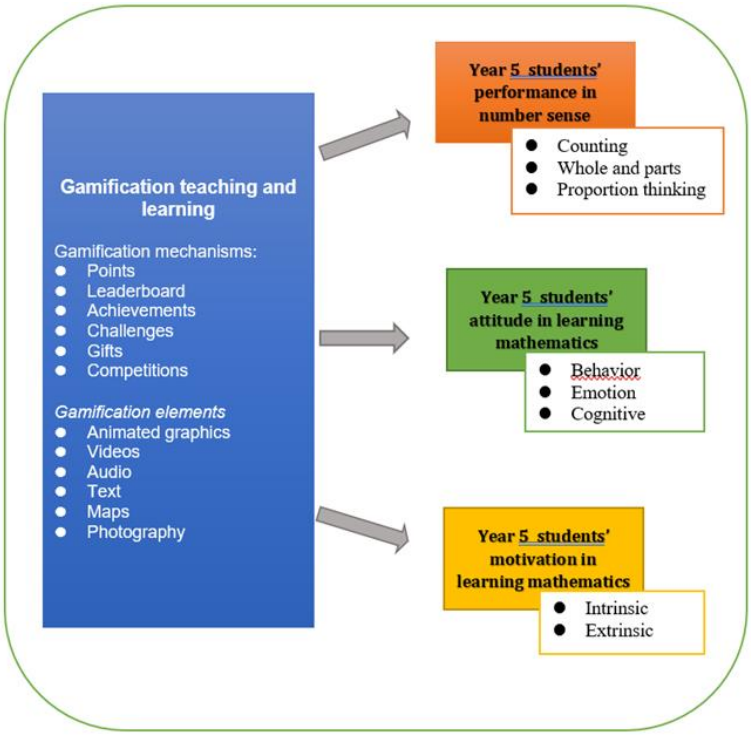

Figure 1: Conceptual Framework

Methodology

This study utilizes a quasi-experimental design due with one control and one intervention group. The two groups consist of two year 5 classes (n=30 for each class) who are at par with each other in terms of mathematical achievement. Both the intervention and control groups had to take a pre-test before the experiment begins. Following the Pre-tests, the intervention group received eight sets of 60-minute treatment sessions using gamification teaching and learning while the control group went through revision exercise handouts. Following the conclusion of all treatment sessions, both groups were given a number sense post-test. In addition, both groups were given a motivation and attitude survey. The instruments used in this study were validated by one senior lecturer, an Excellent mathematics teacher and a year five mathematics teacher. A series of t-tests were conducted the measure the effectiveness of the gamification intervention on students' number sense. Meanwhile, Mann Whitney U test was conducted to measure the difference in attitude towards mathematics and motivation toward learning mathematics between the intervention and control group.

Findings and Discussion

The Effects of Gamification on Students' Number Sense

Table 1
Paired Sample Statistics of Pre-test and Post-test of Intervention Group

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-test	19.03	30	7.374	1.346
	Post-test	30.77	30	5.618	1.026

Table 2
Paired Sample Test of Pre-test and Post-test of Intervention Group

		Paired Differences							
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of thet Difference			df	Sig. (2-tailed)
					Lower	Upper			
Pair 1	pre-test – post-test	-11.733	2.815	.514	-12.785	-10.682	-22.827	29	.000

The average pre-test and post-test mean scores for the study's intervention group were 19.03 and 30.77, respectively. The mean difference of 11.733 is statistically significant ($p<0.05$).

Comparison of Students' Motivation towards Learning Mathematics with and without Gamification

Table 3
Ranks of Students' Motivation towards Learning Mathematics with and without Gamification

	Group	N	Mean Rank	Sum of Ranks
motivation score	control	30	15.50	465.00
	experimental	30	45.50	1365.00
	Total	60		

Table 4
Results of Students' Motivation towards Learning Mathematics with and without Gamification

	Motivation score
Mann-Whitney U	.000
Wilcoxon W	465.000
Z	-6.696
Asymp. Sig. (2-tailed)	.000

a. Grouping Variable: group

According to the findings of this study, the intervention group of this study exhibited higher levels of motivation after participating in the intervention session. It indicates that the gamification approach to teaching and learning is successful in stimulating their interest in education. When it comes to school, students who can self-motivate themselves have a much better chance of reaching their educational goals and growing up to their best potential. To reach one's goals, both learning and teaching must be done with utilize. This is always true, no matter what is being done. Because of this, the students' general sense of well-being gets better, and as a direct result of this, they act in a more positive way.

Comparison of Students' Attitudes towards Mathematics with and without Gamification

Table 5

Ranks of Students' Attitudes towards Mathematics with and without Gamification

	group	N	Mean Rank	Sum of Ranks
Attitude score	control	30	15.50	465.00
	experimental	30	45.50	1365.00
	Total	60		

Table 6

Results of Students' Attitudes towards Mathematics with and without Gamification

	attitude_score
Mann-Whitney U	.000
Wilcoxon W	465.000
Z	-6.676
Asymp. Sig. (2-tailed)	.000

a. Grouping Variable: group

After the treatment session, there was a significant difference in the effect size of the intervention group for each item. The intervention group was the one that received the treatment. This demonstrates that the intervention was carried out with the intention of assisting students in developing more favourable attitudes towards mathematics. If no effort was made to assist students, their academic performance would remain significantly lower than that of their peers with better levels of achievement.

Discussion

The effects of gamification on pupils' number sense

Both the experimental and control groups started with fifth-year students with inadequate number sense. The Pretest showed that both research groups had inadequate number sense. The experimental group improved significantly and had a shift in score distribution after the intervention. This shows that gamification teaching and learning affected the experimental group and that a fun and effective teaching method can improve it. This suggests that the gamification teaching and learning had an effect on the intervention group, and that they had the capacity to improve if a teaching technique that is both effective and enjoyable is adopted (Awang et al., 2013). Additionally, previous studies (Filippou et al., 2018) discovered similar findings regarding the acceptance of gamification. The students just required a specific list of guidelines, and they are driven by the opportunity to exercise their individual initiative and creativity (Rahal, 2010). Because of this motivation, they were able to answer the post-test with competence and confidence in themselves. In this way, the gamification teaching and learning had given them clear commands to follow in order to solve a problem. It had also given them the freedom to make personal choices and the opportunity to be creative while solving mathematical issues, particularly those involving number sense.

According to researchers Gupta and Goyal (2022); Koivisto and Hamari (2019) proposed that incorporating digital game elements such as avatars and badges into educational settings could effectively engage students and facilitate the achievement of learning goals. This hypothesis was based on the belief that millennials, who were known for their extensive involvement in games, would respond positively to these elements and find them enjoyable.

This incentive helped them pass the post-test with confidence. So, gamification teaching and learning gave students clear instructions to address a problem. It also allowed kids to be creative and make personal choices while solving arithmetic problems, especially number sense ones.

This means pupils who follow the treatment session improve faster than those who follow the usual teaching and learning method. The experimental group's ability gap widens following therapy. This may be attributed to "gamification," which incorporates games into schooling. Dichev and Dicheva (2017) say this method may engage pupils in their studies. The experimental group demonstrated significant changes in students' number sense performance, which is consistent with the goal of achieving game-like engagement (Fardo 2014). Gamification aims to increase students' skills, present meaningful learning objectives, engage students, maximize learning, support behavior change, and promote social responsibility.

The experimental group performed differently before and after therapy. It's clear that gamification helped these experimental group students reach their potential following the treatment session. The control group never improves since they follow the traditional teaching and learning method. Gamification for instruction and learning was the sole difference between the experimental and control groups. This study, like Featherstone and Habgood (2019), demonstrated that individuals' engagement with games can positively impact their inclination to incorporate game design elements into learning, potentially leading to improved academic performance when the experience of these elements is more immersive.

Comparison of students' motivation towards learning mathematics with and without gamification

According to the findings of this study, the intervention group of this study exhibited higher levels of motivation after participating in the intervention session. It indicates that the gamification approach to teaching and learning is successful in stimulating their interest in education. When it comes to school, students who can self-motivate themselves have a much better chance of reaching their educational goals and growing up to their best potential. To reach one's goals, both learning and teaching must be done with utilize. This is always true, no matter what is being done. Because of this, the students' general sense of well-being gets better, and as a direct result of this, they act in a more positive way.

In recent years, a number of studies have attempted to clarify the variables that influence mathematical performance (Surur, 2022; Syarifuddin & Atweh, 2021). The majority of studies indicate that motivation is the most influential factor influencing mathematical performance. Specifically, self-related beliefs and motivation have been identified as predictors of mathematics performance (Habók et al., 2020). Motivation, peer relationships, and self-efficacy were identified by Li et al. (2020) as contributing factors to mathematics performance.

There is opportunity in the gamification for both the intrinsic and the extrinsic types of motivation. Both types of motivation can be influenced by rewards. Extrinsic motivation is often the source of the first boost that helps intervention group become engaged in the gamification teaching and learning activities, and this boost can also assist students' motivation remain stable over the course of the learning experience. It is possible for a person's degree of self-motivation to be increased using either the individual's intrinsic or extrinsic sources of incentive.

Comparison of students' attitudes towards mathematics with and without gamification

After the treatment session, there was a significant difference in the effect size of the intervention group for each item. The intervention group was the one that received the treatment. This demonstrates that the intervention was carried out with the intention of assisting students in developing more favorable attitudes towards mathematics. If no effort was made to assist students, their academic performance would remain significantly lower than that of their peers with better levels of achievement. This is comparable to the findings of Wu et al (2013), which suggested that students with low academic performance needed assistance in developing learning motivation and increasing their performance.

Therefore, improving the attitude of students in learning mathematics through the use of a workbook together with the chalk-and-talk method is not going to be helpful. The conventional way of teaching does not have a beneficial effect on the student's attitudes towards mathematics; rather, it has the opposite effect, making such attitudes worse. Again, this demonstrates that there is potential for improvement among students provided that an interesting method that is both efficient and engaging is utilized (Awang et al., 2013).

Conclusion

Overall, the objectives of this study were to determine whether students' achievements in number sense changed as a result of gamification teaching and learning, as well as to improve students' attitudes towards learning mathematics and their level of motivation to do so through gamification teaching and learning. The use of gamification in the teaching and learning of number sense proved beneficial in that it enabled students to answer quickly and easily while concurrently boosting their self-confidence to answer independently. This was accomplished by employing gamification. Therefore, a teacher must use a straightforward and efficient method to optimise learning and instruction. When students study in a positive environment, their learning self-esteem increases indirectly. Children will be more successful in school if they have self-assurance and an interest in the subject matter. Effective teaching techniques, such as gamification teaching and learning, can not only increase a student's self-confidence, but also their conceptual comprehension and memory of number sense.

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