# Non-digital gamification: Effects of teaching on mathematics achievement and student behavior

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## ABSTRACT

**Purpose:** This study examined the effect of non-digital game-based teaching methods on student achievement in mathematics particularly in fractions.

**Design/Methodology/Approach:** A quasi-experimental design involving 100 students from primary schools in the state of Perak. Two groups (the control group and the experimental group) were formed where the control group went through conventional learning while the experimental group used non-digital gamification learning methods. Data was collected using four instruments: the fraction topic mathematical achievement test, the math textbook (control group), the math textbook and fraction gamification kit (experimental group) and observation.

**Findings:** Studies show that students who use NDGBL score better in math achievement tests (fractions) than those who study topics using conventional methods. There is a better effect on changing student behavior when using the NDGBL method than the conventional method.

**Implications, Conclusion and Contribution of Literature:** This study provides empirical evidence about the NDGBL method for learning fractions. Findings also suggest that NDGBL is an innovative method that is still relevant and can be used to increase human capital and learn about fractions and mathematics.

***Keywords:*** *Addition, Fraction, Gamification, Mathematics, Students, Subtraction.*

## 1. INTRODUCTION

Fractions are seen differently than whole numbers. Fractions have a unit property which makes it difficult for students. According to Mohd Afifi, Anis Norma, Mohammad Ikhwan and Mohd Faiz, (2021), students often have four misconceptions in fraction involving basic operations: systematic errors, random errors, carelessness and lastly the mistake of answering the question. An investigation found that the students had the following problems with fractions: 1) lack of understanding of the process of addition and subtraction of fractions. 2) They don't know how to change the denominator of the same fraction. 3) Miscalculation in fractional operations. 4) They don't know how to convert mixed fractions to improper fractions and vice versa. 5) The fractional process is incorrectly implemented. Students make mistakes when adding fractions. Figure 1 is often seen by teachers when reviewing exercise books, exams and assessments in class.

Misconceptions often occur when students do not understand clearly. When adding or subtracting fractional numbers, students are still thinking about the concept of adding or subtracting whole numbers. This is further shown in Figure 1 by the student's answers to the misconceptions made through questions numbered 1,2,3,4 and 6. Mistakes are also seen in questions 7 and 8. The misconception that can be seen is adding fractions in parallel, i.e. numerator and numerator. They also make mistakes when they add denominators and numerators. The mastery of fractions has an impact on algebraic knowledge and later math achievement, hence, this issue needs to be addressed immediately (Siegler & Lortie-Forgues, 2017).



***Nurture****: Volume 17, Issue 4, 504-515,* ***2023***
***Online ISSN****: 1994-1633/* ***Print ISSN****: 1994-1625*
***DOI****: 10.55951/nurture.v17i4.388|* ***URL****:* www.nurture.org.pk

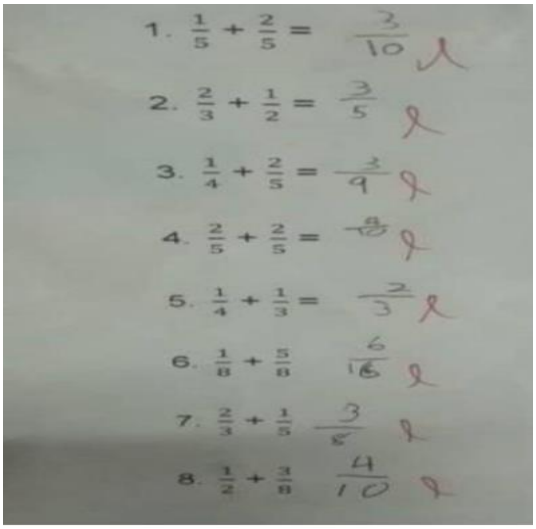


**Figure 1.** Student errors in the operation of adding fractions.

This misunderstanding needs to be resolved by implementing effective teaching and learning through the use of teaching aids (Mohd Amin, Mohd Faeez, Kalthom, Muhammad Syakir, & Murihah, 2016). Therefore, transformation needs to be done and the development of innovative materials is very important. The effectiveness of using teaching aids can no longer be denied. Teaching aids can help teachers implement effective teaching and provide clearer explanations than if they were not used (Mohd Amin et al., 2016).

Mathematics teachers often use specific teaching and learning methods. The literature shows that the said teaching method can have a good effect on their teaching. They use lecture methods, group discussions and inquiry methods. Mathematics teachers also use cooperative learning methods and project-based learning (Mohd Afifi, 2017; Noraini, 2005). Various ideas for teaching methods have been proposed by researchers to improve teaching. However, there has been no change in the teaching methods of mathematics teachers. They still use the same method. They also use the chalk and discussion method in teaching mathematics. They focus on student academic achievement only (Azhari & Zaleha, 2013; Koh, Choy, Lai, Khaw, & Seah, 2008; Li & Pu, 2023; Mohd Afifi, 2017). The teacher-centered method is still practiced and only one-way communication occurs (Mohd Afifi, Nor'ain, & Mazlini, 2016).

For mathematics, teachers often use seven practices in their teaching sessions: 1) Emphasis on the concept of the topic. 2) Polya model system. 3) Give appropriate examples related to mathematics in the explanation. 4) Use of realistic aids. 5) Use a mind map. 6) Terms that are easy to understand. 7) Heuristic models (Norain, Marzita, Mazlini, Mohd Faizal Nizam, & Amalina, 2015). Teaching is less effective when the teacher only focuses on the mind without the help of teaching aids, gives ineffective training, uses memorization techniques instead of understanding and causes students' own attitude problems (Noraini, 2005).

In conclusion, the practice of mathematics teachers in teaching is still at the same level based on the literature review. Therefore, the transformation of teachers to implement teaching and learning that can increase human capital is very necessary. The teaching and learning should foster thinking skills, leadership, communication and collaboration. The first step is to use appropriate and innovative teaching aids. Innovative materials can provide a better effect. The appropriate approach to use is a non-digital game-based learning approach (NDGBL). This approach is able to create active and meaningful learning.

The NDGBL approach has various elements. 1) fun, 2) exploration, 3) providing experiences that encourage interest, 4) clear learning outcomes, 5) players have authority, 6) receiving rewards, 7) competition between students and 8) less risk (Ke, Xie, & Xie, 2015). NDGBL usually uses physical materials such as dice and cards. In addition, NDGBL also has game boards or teacher innovation materials. NDGBL elements are applied to solving problems (tasks) while playing. The assignment is a test for students to plan the correct strategy. They are also given the freedom to investigate and explore assignments without teacher guidance (Park & Lee, 2017). A student's success in mastering a skill depends on the completion of multiple tasks. Students who complete many assignments are seen as having more skills. NDGBL processes and activities usually involve students' daily lives.



***Nurture**: Volume 17, Issue 4, 504-515, **2023***
***Online ISSN**: 1994-1633/ **Print ISSN**: 1994-1625*
***DOI**: 10.55951/nurture.v17i4.388| **URL**: www.nurture.org.pk*

Each process and activity of the NDGBL assignment is given clear explanations so that students understand the NDGBL guidelines. This element gives exposure to students in relation to real world life (Radzi, Ying, Abidin, Ahmad, & Zainol, 2017). The elements of fun, competition and challenge in the NDGBL approach guided by the discussion process between students encourage them to think critically and creatively. This approach also involves certain guidelines and rules that can improve the discipline of student behavior (Hromek & Roffey, 2009). On the other hand, the conventional approach only involves the teacher's explanation, delivering the content, reading and memorizing the content information and implementing reinforcement through question drills in the textbook (Nair, Yusof, & Hong, 2014). When the literature review is done, there are differences of opinion between digital game-based learning and NDGBL. The difference covers student interaction. For example, a digital monopoly game versus a non-digital monopoly game. The social interaction of students in the NDGBL group was significantly better than that of the DGBL group (Fang, Chen, & Huang, 2016). They prefer monopoly board games to digital monopolies. The benefits of NDGBL are: increased familiarity and more satisfied playing and increased sympathy towards opponents (Fang et al., 2016).

Rahutami, Suryantoro, and Rohmadi (2019) also stated that NDGBL is better than DGBL. Among the aspects evaluated are social (respecting each other), critical thinking skills, communication and collaboration. This is because there is a face-to-face speech relationship, eye contact with each other (visual) and body movements that can be seen by students compared to DGBL. DGBL is just an audio connection. In addition, NDGBL is also able to have an impact on several things such as 1) teamwork, 2) interaction skills, 3) analyzing information, 4) planning skills, 5) inquiry skills and 6) decision-making skills. Previous studies have also shown that NDGBL creates meaningful learning that includes a fun environment, active learning and two-way interaction between teachers and students as well as between students and teachers (Chung, Yen-Chih, Yeh, & Lou, 2017).

NDGBL has also been studied in other fields such as the study of Cesur (2019) (English Grammar), Ramly, Kamal Ikhsan, Abdul Rahman, and Ramlan (2017) (Biology), Junaidah, Norlaila, Faizan, and Nur Syazwani (2016) (Accounting) and Bankole (2018) (Biology). Their studies have proved that the NDGBL approach benefits students. Some studies have also been done in mathematics such as those carried out by Michael and Anugwo (2016); Chung et al. (2017); Elofsson, Gustafson, Samuelsson, and Träff (2016); Scalise, Daubert, and Ramani (2020) and Vitoria and Ariska (2020). Their studies cover the topics of algebra, geometric shapes, geometric lines, numbers and angle measurements. The NDGBL approach is proven to have a positive impact on student interest, engagement and achievement. For example, the use of NDGBL which is a game card by Busadee and Klieosinak (2017) and a game board by Chung et al. (2017). Their study shows that NDGBL has an impact on meaningful teaching. A quasi-experimental study of the topic of angle measurement between the NDGBL group and the traditional approach with primary school students showed significant differences. Students in the NDGBL group have better achievement than students in the traditional group (Vitoria & Ariska, 2020). The board game "snakes and ladders" was used by the NDGBL group for three teaching and learning sessions. Small group clusters formed in NDGBL groups increase interaction, communication, cooperation and collaboration between group members during group discussion sessions to complete assignments and activities. This can also happen when all members of the group are required to ensure that they understand the rules of the card game. In this case, they need to ensure that the received fraction cards are settled with the correct fraction operation. In summary, the research literature also shows that NDGBL studies have been carried out in various fields including mathematics. However, there is still a lack of research that focuses on NDGBL with fractional topics.

A literature review shows that NDGBL is rarely tested to improve mathematics achievement especially school mathematics (Aldemir, Celik, & Kaplan, 2018; El-Hilly et al., 2016; Grangeia, De Jorge, Cecílio-Fernandes, Tio, & de Carvalho-Filho, 2019; Hanus & Fox, 2015; Leclercq, Poncin, & Hammedi, 2017; Mavletova, 2015; Mitchell, Schuster, & Drennan, 2017; Tu, Hsieh, & Feng, 2019). Therefore, the need to carry out NDGBL studies in mathematics is very high and studying the impact of NDGBL is particularly appropriate to increase students' interest in mathematics education. In the context of this study, NDGBL is using a gamification kit developed by the researcher.

In Malaysia, students in mathematics from 1 to 6 years old will be taught some basic topics. Among them are numbers, number operations, basic measurements, geometry, algebra and statistics (Malaysia Education Ministry, 2014). However, the researchers chose fractional topics based on several justifications. A very unique property of fractions is that they have both a denominator and a numerator. This property is different compared to whole numbers. Students cannot distinguish the unique nature of the fraction (Braithwaite, Tian, & Siegler, 2018) . This



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***Online ISSN**: 1994-1633/ **Print ISSN**: 1994-1625*
***DOI**: 10.55951/nurture.v17i4.388| **URL**: www.nurture.org.pk*

topic often occurs as a misunderstanding as explained by Zakiah, Saad, Arshad, Yunus, and Zakaria (2013); Braithwaite et al. (2018); Saparwadi, Purnawati, and Erlian (2017) and Tian and Siegler (2017).
Studies show that primary school students have difficulty learning the concepts and skills of fraction (Gaetano, 2014; Siti Nuhani & Maat, 2018). Fractions have a relationship with other topics such as algebra. This can result in students becoming weak in mathematics (Siegler & Lortie-Forgues, 2017). Students' maths performances in secondary school are affected by their lack of fractional knowledge (Siegler & Pyke, 2013). One of the ways to overcome this problem is by using appropriate teaching aids. Teaching aids are proven to have a positive effect on teachers' teaching and learning (Mohd Amin et al., 2016). The creativity and critical thinking skills of teachers are very important in developing appropriate teaching aids. Therefore, the study of gamification kits in the form of NDGBL on the mathematical achievement of the topic of fractions is significant.

## 2. METHODOLOGY

*2.1. Research Design*

A study with a quasi-experimental design was implemented. Two groups were formed: the experimental group and the control group. The experimental group used the NDGBL approach while the control group used the conventional approach. This study was carried out during school hours with an existing group of students.

*2.2. Participants*

100 students from two national schools in the state of Perak were selected as a study sample. The study sample was selected and reviewed from the perspective of homogeneity for both schools based on their mathematics achievement. In addition, both samples have not yet learned about fractions. In this study, 50 people from school Y participated in a control group (conventional teaching) while 50 people from school Z participated in an experimental group (gamification learning). With this method, the interaction between the two groups can be controlled while at the same time increasing the validity of the study.

*2.3. Instrument*

There are four instruments used in this study: a) Fraction topic mathematical achievement test. b) Math textbook (control group). c) Math textbook and fraction gamification kit (experimental group). d) Observation. Specifically, the control group will use textbooks as a teaching guide while the experimental group will use textbooks and fractional gamification kits as teaching interventions. Both groups were also given the same task. The materials used in this study also conform to the learning outcomes of the fraction topic as contained in the Mathematics Curriculum and Assessment Standard Document (CASD) year 3. CASD is the most important document for teachers in planning and implementing teaching and learning activities. The study instrument has also been evaluated and verified by three experts consisting of outstanding mathematics teachers, School Improvement Specialist Coaches (SISC+) and a senior lecturer in mathematics. Experts are appointed with more than 10 years of experience in mathematics particularly teaching and learning mathematics in primary schools. During the study, the mathematics teachers who handled both groups were given a daily lesson plan (LP) as a guide for the implementation of the fraction which increased the validity of the study. According to the format and standards of the Malaysian Ministry of Education, a lesson plan is designed that contains learning outcomes and steps for the implementation of activities during the teaching and learning process. In the assessment phase, all samples for both groups were given a math achievement test on fractions after the intervention process was given.

*2.3.1. Control Group (Year 3 Mathematics Textbook)*

For the control group, fractions were taught conventionally using mathematics textbooks as the main reference. The teacher used the examples and exercises found in the textbook as activities in the classroom. The teacher gives at least 3 questions to the students and explains how to solve them. The questions also have diversity from a taxonomic aspect. Students are then given five exercises to complete. The discussion is done after 20 minutes. The teacher asks the students to write their answers on the white board and explain their answers. This process is carried out until all five questions are discussed.



***Nurture**: Volume 17, Issue 4, 504-515, **2023***
***Online ISSN**: 1994-1633/ **Print ISSN**: 1994-1625*
***DOI**: 10.55951/nurture.v17i4.388| **URL**: www.nurture.org.pk*

*2.3.2. Experimental group (Fraction Gamification Kit and Math Textbook)*

The experimental group learned the fraction using the fraction gamification kit. This fractional gamification kit is inexpensive, easy to produce by teachers and students, portable can be used anywhere and anytime and has challenges. This gamification kit is implemented to resemble a children's donkey card game. The materials contained in this fractional gamification kit consist of fractional gamification cards, reward boards, reward badges and solution boards.

*2.3.2.1. Fraction Gamification Cards*

This fraction gamification card has five main themes: animals, information technology equipment, carpentry equipment, types of sports and plants. Each theme has seven cards. The cards include information related to the theme, fraction values and the basic operations involved. Examples of cards are as follows:

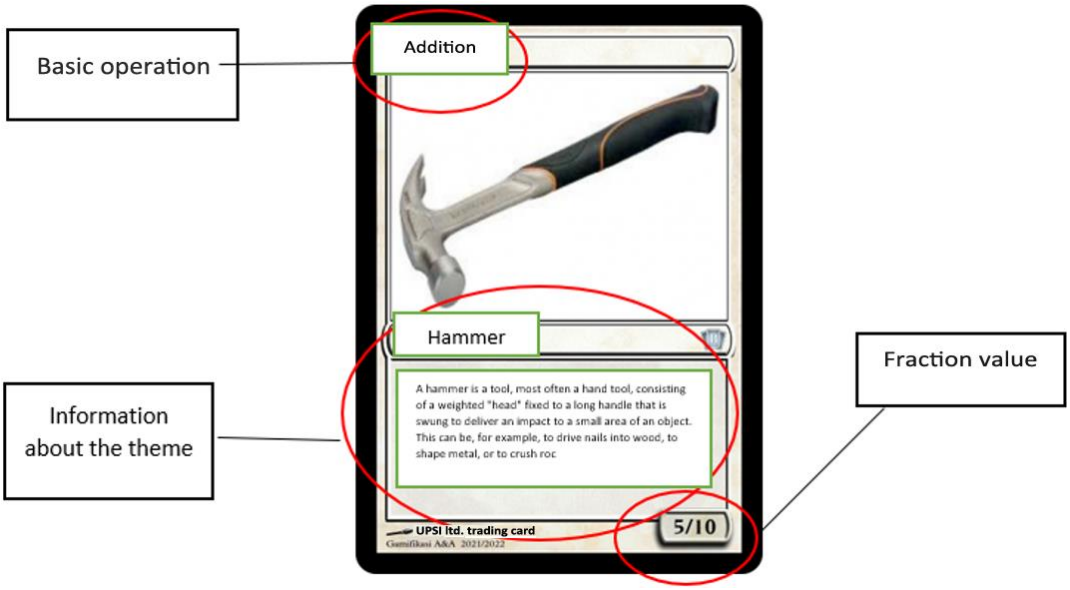


**Figure 2.** Example of Card.

*2.3.2.2. Reward Board*

This reward board is used to display badges earned by students. Badges can be given to individuals or groups depending on the implementation of the game. The reward board is as follows:

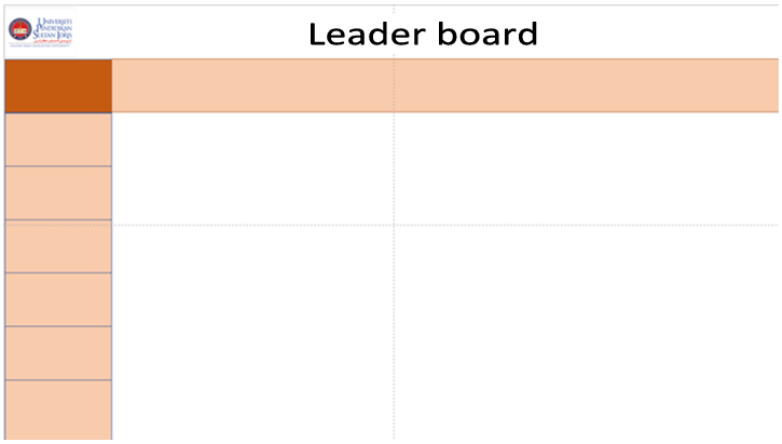


**Figure 3.** Example of leader board.



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*2.3.2.3. Reward*

One of the elements of gamification is rewards. In these fractional gamification kits, a badge in the form of a smiley icon is given. These badges are collected by students on the reward board. Student ranking is determined by the number of badges earned from games in these gamification kits. Examples of badges are shown in Figure 4.

**Figure 4.** Example of badges.

*2.3.2.4. Fraction Solution Board (Troubleshooting Board)*

This fraction solving board is used by students to perform fraction comparison operations or asic operations on two fractions. This fraction solving board uses the concept of "SAKE BEDA" as explained by Mohd Afifi, Anis Norma, Mohammad Ikhwan, and Mohd Faiz (2021). SAKE BEDA means that when the value of the denominator is the same, it is maintained while when the denominators are different, the numbers need to be multiplied to equalize. The board is shown in Figure 5.

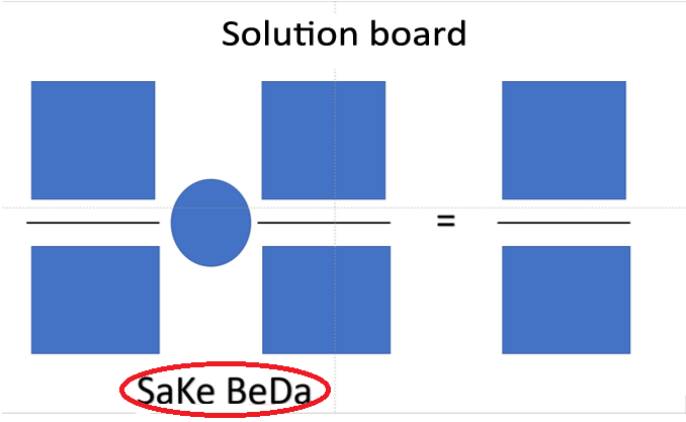


**Figure 5.** Solution board.

These gamification kits are played using the same rules as games such as donkey cards, snap cards and king cards. Students who win each round are given a badge and displayed on the leader board. The student with the most badges is considered the winner. The teaching and learning process is also the same as in the control group but with gamification kit game activities and the Sake Beda concept for the topic of addition and subtraction of fractions.

*2.4. Procedure*

This study was conducted with an application for its implementation to the Malaysian Ministry of Education. A pilot study is conducted after the application is approved. The mathematical achievement of the pilot study sample and the actual study sample is equivalent. The head teacher received a briefing on the purpose, the process and the administration of the study. In addition, the researcher also gave tutorial sessions to the teachers who conducted the study for both groups including lesson plans, fractional gamification kits, study instruments and training. Teachers for both groups were given training and guidance. Control group teachers were guided using a conventional group lesson plan while experimental group teachers were given guidance and training on group



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intervention implementation procedures. Only teachers with over 10 years of experience were selected as facilitators for both groups. During the intervention implementation process, the control group will receive conventional interventions such as discussions, training activities and discussions in front of the class. The experimental group uses gamification kits as an additional activity. The implementation period is four weeks. Avoid external factors such as additional classes, discussions between peers and references to other sources of information that can affect the internal validity of the study. After that, the postal test lasted for one hour. The researcher also used the observation method during the intervention process which shows that there are positive behavioral changes for students. The checklist for the observation session is shown in Table 1. Students are observed 10 times during teaching and learning.

**Table 1.** Student behaviour checklist with 10 observations.

| Student behaviour | O1 | O2 | O3 | O4 | O5 | O6 | O7 | O8 | O9 | O10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Talking unrelated to the topic | | / | | | / | | | / | | / |
| Leave the classroom | / | / | | | / | | | | | / |
| Walking from one place to another | | | / | | | / | | | | |
| Thinking elsewhere (Chestnuts) | | | | | / | / | | | | |
| Doing other work | | | / | | | | | | | |
| Interrupting other students physically | | | | / | | | | / | | |
| Try to attract attention | | / | | / | | / | | / | | |
| Sharpen a pencil | | | | / | | / | | | | |

## 3. FINDINGS AND DISCUSSION

This quasi-experimental study has tested the research hypothesis through two main methods: independent sample tests and repeated measurements. This can be solved with the help of inferential statistics. However, a few things should be addressed to determine the type of inferential statistical test to be used. Researchers need to ensure all conditions of the parametric test. Among the parametric test conditions that must be met are the normality of the distribution, the scale used and sampling (Chua, 2006). The basic conditions for using the Analysis of Variance (ANOVA) test need to be reviewed. The conditions that must be followed are normality, linearity, equality of variance (Chua, 2014) and outliers (Pallant, 2010). This method is called discovery data analysis ( exploratory data analysis).

The results of the normality test (which is the Kolmogorov-Smirnov test) show non-significant results which means that the value of the analysis results exceeds the significance level of 0.05. This test was chosen based on the recommendations of Coakes (2007). According to him, when the number of samples is more than 100, the Kolmogorov-Smirno test is suitable for testing normality. Those determinations have confirmed that parametric tests of differences can be used. After that, data review from the aspect of equality of variance was carried out using Levene's test (Chua, 2014; Coakes, 2007). Findings show non-significant data with $p>0.05$. This means that the variance value of the dependent variable across the experimental group and the control group is the same. Data outliers are also checked through box plots. The results of the review found that there were outliers on the math pre-achievement test (ID numbers 25 and 30) and the math achievement post test (ID number 29). However, the trimmed mean values of the two tests did not differ from the original mean. So the outlier is retained (Pallant, 2010). The data also show that all dependent variables are linearly correlated with each other through the Pearson correlation test ($p>0.05$) and scatterplot graphs (Chua, 2014). The steps are used to check the prerequisites for the use of the ANOVA inference test before the data is analyzed. In conclusion, ANOVA test analysis is suitable to be used to answer the research hypothesis.

Both analyses were conducted to see if there were significant differences between the two groups in the mathematics (fraction) achievement variable. Covariate analysis can be determined through pre-testing. The pre-test data is used as a covariate if there is a difference in the pre-test mean between the treatment group and the control group. ANOVA test analysis is used to answer the next analysis if this initial analysis does not show a difference. The analysis of covariance (ANCOVA) test will be conducted if the result is different.

The results of the ANOVA analysis show that there is no significant difference in the pre-test mean of mathematics (fraction) achievement between the treatment group and the control group [$F(1,98)=1.49$, $p>0.05$] through Table 2. This proves that the level of mathematical achievement of both groups was the same at the beginning of the



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experiment. The pre-test difference between the two groups can be determined based on the first hypothesis through ANOVA test analysis.

**Table 2.** ANOVA test analysis of differences in mathematics pre-achievement tests between the treatment group and the control group

| **Univariate test** | | | | | | |
|---|---|---|---|---|---|---|
| **Dependent variable: Pre mathematics achievement** | | | | | | |
| | **Sum of square** | **Df** | **Mean squared** | **F** | **Sig.** | **Partial Eta squared** |
| Difference | 128.133 | 1 | 128.133 | 3.877 | 0.059 | 0.122 |
| Error | 925.333 | 98 | 33.048 | | | |

**Note:** * Significant at the confidence level p<0.05.

The data were analysed using independent-samples ANOVA. Findings show the effect of teaching methods on the mathematical achievement of sample fractions. Findings are significant with F (1,98)= 4.42, p=0.04. The achievement of the experimental group (M=14.83, SD, 3.16) is better when compared to the achievement of the control group (M=11.95, SD=5.39) as shown in Table 3.

**Table 3.** Mean and standard deviation of fraction topic mathematics achievement

| **Group** | **Mean** | **Standard deviation** |
|---|---|---|
| Control (Conventional) | 11.95 | 5.39 |
| Experimental (NDGBL) | 14.83 | 3.16 |

Findings show that the gamification method provides good benefits and has an effective effect on the mathematical achievement of the fraction compared to the conventional method with a mean difference of 2.88 due to the characteristics of the gamification method that facilitate the learning of a fraction of the study sample. Through this method, the sample is more motivated to try something new. This is supported by the statement of Mohd Afifi, Nor'ain, Mohd Faiz, and Muhamad Ikhwan (2019) where the fun factor and playing experience can increase student engagement.
Findings show positive changes in student behaviour during the use of NDGBL (see Figure 6).

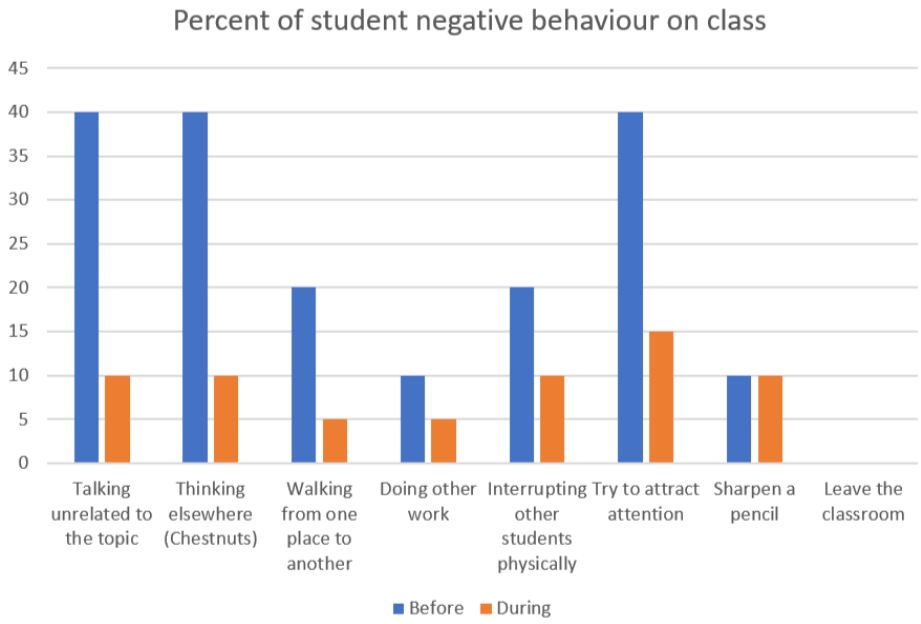


**Figure 6.** Percent of student behaviour before and during intervention.

Gamification also builds meaningful learning through elements of challenge, discovery, goal-setting, reward and collaboration (Ke et al., 2015). Creativity and critical thinking skills can be seen in students. When the player tries



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hard to complete the game's tasks and goals, they feel satisfied especially when solving challenging problems. They will also continue the game until they can complete the goal of the game (Palmer, 2016). Participants are more focused on completing the task of the game because the characteristics of the game require them to think. As seen from the difference between gamification and conventional methods, gamification kit groups give students the opportunity to interact, collaborate, exchange solution ideas and discuss. This gamification method also allows students to help each other solve problems together. This is because the instructions of the game require those elements to be implemented (Wang & Zheng, 2020).

Students in the conventional group are easily distracted, unwilling to participate and do not go beyond what is expected of them. This is proven when observation is carried out while they are learning without involving gamified materials. They are not active in the learning process. Negative behavior can be seen through observations such as 1) playing with a pencil, 2) looking at the time on the wall clock or watch, 3) daydreaming, 4) playing and walking and 5) going to the toilet. This shows that the use of gamification kits is very important as stated by Vitoria and Ariska (2020). Although teachers have their own way of teaching fractions such as the technique of memorizing rules, conceptualizing is also important in learning fractions. Therefore, the need for manipulative materials is very important during the teaching and learning of fractions.

Knowledge can be retained longer if visual activities and educational games involve physical activity. Gamification has an advantage in NDGBL (Muhamad, Zakaria, Salleh, & Harun, 2018) over memorizing facts and completing drills through conventional learning methods. Therefore, the educational game increases the potential and skills of students (Hery, 2018).

For example, there is a competition between students to answer questions through a gamification kit allowing them to have a fun experience. This simultaneously builds a memory that can be remembered until they grow up. The effect of the NDGBL method is consistent with previous studies that show that it improves students' understanding of the concept of a topic such as polynomial operations (Barros, Carvalho, and Salgueiro (2019)), algebraic concepts (Andini & Yunianta, 2018), mathematical creativity (Park & Lee, 2017) and geometric concepts (Pratama & Setyaningrum, 2018).

## 4. CONCLUSION

In the context of teaching methods, the findings of this study highlight the role of NDGBL in improving the learning of sample fraction topics. NDGBL involves games that have materials such as cards, badges, solution boards and reward boards. All of these materials are concrete and are able to improve the learning atmosphere by providing an interesting, interactive, conducive environment and meaningful teaching. This happened in the experimental group. The performance of the experimental group was seen to be better than that of the conventional group. This study also has implications for mathematics teachers who should practice it in their teaching and learning especially in fractions.

This study provides empirical evidence and fills the gap left by previous studies on fractions (mathematics) and the gamification approach in education. In addition, this study also proves that students' behaviour about their perception of mathematics can be changed through learning methods that are interesting and suitable for them.

The results of the overall research found that NDGBL is one of the learning media that contributes to creating an effective learning environment.

Nowadays, schools have implemented learning activities that make students happy and interested in learning mathematics which has been difficult and boring through NDGBL. Teachers and students want games that refer to the mathematics subject. Therefore, this research can be used as a reference for teachers and researchers.

This study was only carried out in two schools. The two schools are also non-Dual Language Program (DLP) schools. The teaching and learning of mathematics are carried out in the Malay language. Therefore, it is suggested that future studies use samples from DLP schools.

Researchers also suggest that the study can compare samples from urban and rural areas. NDGBL also needs to be researched more deeply regarding the topic of fractions for students of various levels and other subjects.

**FUNDING**

This research is supported by Universiti Pendidikan Sultan Idris through Geran Galakan Penyelidikan Universiti 2021 (Grant number: 2021-0049-107-01).

**INSTITUTIONAL REVIEW BOARD STATEMENT**

The Ethical Committee of the Sultan Idris Education Study, Malaysia has granted approval for this study on 16 August 2021 (Ref. No. 2021-0049-107-01).

**TRANSPARENCY**

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

**CONFLICT OF INTEREST**

The authors declare that they have no competing interests.

**ARTICLE HISTORY**

Received: 17 April 2023/ Revised: 20 July 2023/ Accepted: 31 July 2023/ Published: 8 August 2023

**AUTHORS' CONTRIBUTIONS**

All authors contributed equally to the conception and design of the study. All authors have read and agreed to the published version of the manuscript.



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