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Increasing the Ability to Understand Mathematical Concepts through the Team Games Tournament (TGT) Model Assisted by the PhET Application

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Abstrak

This research seeks to assess the enhancement of third-grade elementary students' understanding of mathematical concepts comprehension through the Team Games Tournament (TGT) instructional approach, supported by the PhET application, compared to traditional teaching methods. The study employs a quasi-experimental method using a nonequivalent control group design. A total of 63 third-grade students participated, selected through purposive sampling. Data were collected through multiple techniques, such as tests, observations, discussions, and photo and video records. The assessment tool used was a descriptive test measuring mathematical concept understanding and is stated to have met the requirements for content validity, construct validity, reliability, level of difficulty, and differentiation. The data analysis technique for hypothesis testing uses IBM SPSS Statistics 2.6 software, namely the normalized n-gain hypothesis test. As indicated by the research results, students' ability to understand mathematical concepts at SDN Pancasila Lembang experienced a significant increase after receiving learning using the Team Games Tournament (TGT) instructional approach supported by the PhET application. This is proven by the results of the n-gain data test calculation, which is 0.36 in the medium category. The posttest average score for the experimental group was 67.78 and the posttest average score for the control class was 30.32. This indicates that the improvement in mathematical concept understanding in the experimental group surpasses that of the control group. Consequently, it can be concluded that the Team Games Tournament (TGT) learning model, supported by the PhET application, is a recommended alternative for enhancing elementary students' ability to grasp mathematical concepts.

Keywords: Ability to Understand Mathematical Concepts, Team Games Tournament (TGT), PhET

INTRODUCTION

Mathematics is a field of science taught throughout the world in formal schools (Khotimah, 2021, p. 2). Mathematics is a universal science that advances human application power and has a crucial role in various other scientific disciplines. Mathematics also contains abstract concepts, and understanding them requires high-level thinking abilities. Understanding mathematical topics requires patience, persistence, attention, and high motivation (Sugiyamti, 2018, p. 178). Then, mathematics is a field that is interrelated and inseparable, so the concepts are related to each other (Agustina & Fuadiah, 2018, p. 52). Thus, students must learn mathematics, as it helps sharpen and develop their thinking patterns, enabling them to achieve more systematic and structured thinking.

Learning mathematics can hone thinking skills and become a foundation for the development of other sciences such as computers, engineering, and economics (Simbolon et al., 2020, p. 78). This is in line with the benefits of learning mathematics, namely that it can teach them to think creatively and critically so that they do not easily admit information that is not certain to be true in life and students will also be able to verify the information they receive (Hidayat & Rahmi, 2022, p. 24).

Mathematics in elementary school also prepares them to think rationally, study deeply, be structured, considerate, innovative, and collaborate. These skills are important to enable students to accumulate and use knowledge so that they can survive in a future that is never stable, uncertain, and competitive (Ginanjar, 2019, p. 122). Therefore, learning mathematics is very important to learn because almost all human activities are related to mathematics (Kusmanto & Marliyana, 2014, p. 62).

However, the facts in the field differ because teachers do not use varied learning media and still fully apply conventional models. Then, in light of the observational findings by the research team as well as the educators, it was found that the majority of students in the class do not want to memorize formulas, there is a decrease in motivation, fear of mathematics subjects, lack of interest in mathematics lessons, lack of understanding of mathematical concepts, and no desire to learn mathematics, especially in story matters. On the other hand, teachers also experience difficulties in teaching mathematical concepts. One of the reasons is that teachers have to pursue the next material, even though the material being taught is not yet complete and the children do not understand it correctly.

Based on the problems described through observations, it is known that some students are still below the Kriteria Ketercapaian Tujuan Pembelajaran (KKTP). As shown by the grades of class III.1 students, their mathematics still has a low average score. The KKTP for mathematics is set at 65. 31 of the students in class III.1 is only 17, some of whom pass the KKTP, meaning that the passing percentage is only limited to 54%, while 45% of students do not pass. This is in line with Buyung dkk. (2022, p. 50) that classes that are not conducive will not master concepts, the media used is inadequate, concentration is low, and students' discipline is also low. Meanwhile, research was carried out Aisyah dan Firmansyah (2021, p. 404) it was noted that students who rely solely on memorizing formulas struggle to grasp the underlying concepts of mathematics lessons.

So, the problems found include the ability to understand mathematical concepts. According to Yani dkk. (2022, p. 440) Understanding mathematical concepts is a skill that must be possessed to understand the content of the lesson. Not only do they understand certain concepts, but they must also be able to express these concepts directly, correctly, effectively and with precision when dealing with mathematical problems. Alternatively, understanding mathematical concepts will help solve problems, namely mathematical problems and challenges that they will face in the future when entering the world of work (Radiusman, 2020, p. 7). Understanding mathematical concepts refers to seven indicators, such as 1) Defining the concept through spoken and written communication; 2) determining and generating instances and non-instances; 3) applying models, graphical representations, and symbols to convey a concept; 4) modifying one type of representation into a different form; 5) recognizing different meanings and interpretations of a concept; 6) analyzing the properties of a concept and understanding the scenarios in which they are effective; and 7) compare and contrast the concepts (Arsiyanto et al., 2021, p. 4).

Based on this description, the solution needed is to implement a learning model in the learning process, especially in mathematics subjects. To encourage participation, teachers must create learning that brings them to work together actively in groups. One of these actions is using the Team Games Tournament (TGT) instructional approach supported by the PhET application. The PhET app serves as a visualization tool that allows students to engage, communicate, and respond, helping them retain information longer in their memory and recall it more easily. It can be downloaded on Android or accessed through the website https://phet.colorado.edu/in/, making it convenient for users to integrate into their learning process (Laksono et al., 2023, p. 180). The use of PhET media offers several benefits, including the ability to address time limitations, overcome resource constraints, clarify abstract physics concepts, and simulate phenomena that are challenging to observe directly (Fitriani & Cahyaningsih, 2023, p. 31). The Phet application offers a variety of menu options, including lessons in mathematics, physics, chemistry, and biology. In this research, the researcher focused on mathematics by selecting the arithmetic menu.

This TGT hopes that students will learn actively and collaborate in groups, and students can pass on the knowledge they have gained to their friends. This activity can provide direct experience so that the knowledge gained can stick in his memory for a long period (Rahmat et al., 2018, p. 243). Previous research indicates that TGT also has the potential to increase understanding because they become active, and enthusiastic and enjoy exploring abilities that have been previously understood (Oktavia, 2015, p. 25).

This games-based learning has great potential for the learning process because learning becomes more focused and structured in answering questions (Rahmi et al., 2021, p. 141). This games-based learning is an instructional approach that is not difficult to use because it covers all student exercises and has a game component that every student will like. Next, the teacher will give awards to students with the highest scores they get (Bukhari, 2022, p. 19). This corresponds with the syntax of the TGT learning model, which has 5 stages according to Slavin (in Rusman, 2010, p. 225), like stages class presentations, teams, games, tournaments, and team recognition.

Then, games-based learning is appropriate to use with the PhET application, because it can maximize learning process activities. This is proven by research S. Arifin dkk. (2023, p. 250) that the PhET application has potential for mathematics, seeking a strong understanding of the material and mathematical concepts so that the learning process can run effectively. Then, it is also proven by Banda dan Nzabahimana, (2023, p. 136) that PhET interactive simulation-based learning can improve academic achievement and motivation. This research introduces a new approach by integrating game-based learning, specifically the TGT model, with the PhET application in a more focused context, namely arithmetic. This particular topic has not been extensively explored, especially regarding the use of the PhET application and its impact on student engagement in grasping fundamental mathematical concepts through gamification and hands-on interaction with PhET simulations.

Therefore, by using the Team Games Tournament (TGT) instructional approach supported by the PhET application, researchers hope To advance students' grasp of mathematical concepts. So, this article will examine increasing the comprehension of mathematical concepts in students.

METHOD

This research utilizes a quantitative framework to assess a specific population or sample through data acquisition tools for statistical analysis. This tests the proposed hypothesis. This research is categorized as a quasi-experimental method (quasi-experiment). This study uses a nonequivalent group design where the treatment group and the conventional group are not randomly selected to undergo an initial test, then treatment, and finally obtain a final test score. Nonequivalent group design steps design according to (Sugiyono, 2017, p. 79) this is depicted in Table 1.

TABLE 1. Research Design Nonequivalent Group Design

Group	Pretest	Treatment	Posttest
Experiment	O	X	O
Control	O		O

Information:

O: *Pretest = Posttest*

X: The treatment uses the TGT instructional approach supported by the PhET application

The subjects of this research were all third-grade students at SDN Pancasila for the 2023/2024 academic year. Class III students consist of three classes in one group, namely III.1, III.2, and III.3. Apart from that, this school was chosen because there had been no previous research on the ability to understand mathematical concepts using the TGT instructional approach supported by the PhET application. In this research, two classes were used as research objects: class III.3 as the treatment group was given the application of TGT supported by the PhET application consisting of 31 students, and class III.1 as the control group was given the application of the PBL model with a total of 32 students. To obtain this sample, the researcher used a judgmental sampling approach.

The instrument used for data collection in this research was a descriptive test assessing the ability to understand mathematical concepts which was first validated by experts consisting of one elementary school teacher, one expert in mathematics, and one expert in language. The instrument is tested first to ensure its validity in terms of content/material, construct, and face validity. The description questions consist of five questions that are given before and after treatment, this is done to increase understanding of mathematical concepts. The subject matter chosen in this research was multiplication and division.

The data collection techniques for this research are tests before learning (pretest) and tests after learning (posttest), observation, interviews, and documentation. In this study, the assessment utilized was a written test in the form of essay questions, administered according to a predetermined schedule before and after the learning sessions. The pre-test and post-test consisted of five descriptive questions, with scores for each response ranging from 0 to 4. Additionally, observations were conducted during student activities, focusing on assessing student attitudes and participation throughout the learning process, which employed the Team Games Tournament (TGT) model with the support of the PhET application, as well as the conventional learning model. The interviews conducted were unstructured. The documentation method in this research was used to gather information on the outcomes of students' mathematical concept understanding in third-grade elementary school. This documentation also included capturing photos and videos during the research process. The analytical technique utilized in this study initiates with the use of a normalized gain test to assess the improvement in the comprehension of mathematical concepts. For that use the formula (Hake, 1998, p. 65):

$$Gain\ ternormalisasi\ (g) = \frac{(Score\ posttest - pretest)}{(Ideal\ Score - \ pretest\ score)}$$

To determine the criteria for the gain index, see Table 2 below.

TABLE 2. Gain Index Criteria

Proportion (g)	Interpretation
-1.00 < g < 0.00	There was a decrease
g = 0.00	No increase occurred
0.00 < g < 0.30	Lowly
0.30 < g < 0.70	Currently
0.70 < g < 1.00	Tall

Subsequently, normality and homogeneity tests were performed on the normalized gain data using the Kolmogorov-Smirnov test and the Levene test, respectively. To investigate the hypothesis, a different approach was taken with the Mann-Whitney test on the normalized gain data related to the comprehension of mathematical concepts. All calculations were conducted using IBM SPSS software Statistics 2.6. The hypothesis prepared in the Normalized Gain Test is as follows:

H_0 : There is no considerable difference in the improvement of mathematical concept comprehension between the Team Games Tournament (TGT) instructional approach supported by the PhET application and the traditional learning model for third-grade elementary school students.

H_1 : There is a considerable difference in the improvement of mathematical concept comprehension between the Team Games Tournament (TGT) instructional approach supported by the PhET application and the traditional learning model for third-grade elementary school students.

RESULTS AND DISCUSSION

Based on the research findings, it is evident that the comprehension of mathematical concepts among primary school students, following the initial (pretest) and final (posttest) assessments, yielded the results presented in Table 2 and Table 3:

TABLE 3. Descriptive Statistics of Pretest Data

Grade	Average	Standard Deviation	Minimum	Maximum	Variance
Experimental *Pretest*	49.44	24.993	0	88	624.641
Control *Pretest*	23.13	21.008	0	83	444.716

As shown in Table 2, the control class's average pretest score was 23.13, with a standard deviation of 21.008, the variance of 444.716, a minimum score of 0, and a maximum score of 83. Conversely, the experimental class had an average pretest score of 49.44, with a standard deviation of 24.993, variance of 624.641, minimum value of 0, and maximum value of 88. Table 3 further displays descriptive statistics for the post-test results for both the experimental and control classes.

TABLE 4. Descriptive Statistics of Posttest Data

Grade	Average	Standard Deviation	Minimum	Maximum	Variance
Experimental *Posttest*	67.78	27.825	0	100	27.825
Control *Posttest*	30.32	27.838	0	92	774.959

According to Table 4, the typical posttest result for the control class is shown to be obtained was 30.32 with a standard deviation of 27,838, a variance of 774,959, a minimum score of 0, and a maximum score of 92. Meanwhile, the average post-test score for the experimental class obtained was 67.78 with the standard deviation being 27,825, the variance being 27,825, the minimum value is 0, and the maximum value being 100. Then, after this research obtained the data results from the pretest and posttest, the data was analyzed, where the data could not be concluded that the experimental class had better results than the control, although both groups showed significant improvements in the students' mathematics pretest and posttest. This suggests that other factors outside the observed variables may have contributed to the results observed in both groups. Therefore, based on Table 5, the researchers need to compute the average, standard deviation, minimum value, maximum value, and variance of the n-gain values according to the treatment groups. This will help determine the extent to which the intervention is successful in improving students' understanding of mathematical concepts.

TABLE 5. Data on N-Gain Test Results for Experimental Class and Control Class

Grade	N-Gain				
	Average	Standard Deviation	Minimum	Maximum	Variance
Experiment	0.3569	0.56637	-2.00	1.00	0.321
Control	0.1235	0.27718	-0.60	0.78	0.77

As presented in Table 5, the experimental class has an average n-gain of 0.3569, with a standard deviation of 0.56637 and a variance of 0.321. The minimum and maximum values for this class are -2.00 and 1.00, respectively. On the other hand, the control class has an average n-gain of 0.1235, a standard deviation of 0.27718, and ranges from a minimum of -0.60 to a maximum of 0.78.

Table 5 also indicates that students in the experimental class saw an improvement in their ability to understand mathematical concepts by 0.3569, with the improvement category being classified as moderate, and experienced an increase of 35.67%. Conversely, students in the control class saw an

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improvement in their ability to understand mathematical concepts by 0.1235, with an increase in the low category, and experienced an increase of 11.55%. The gain test outcomes indicate that the improvement in students' understanding of mathematical concepts is similar between the experimental and control classes. To assess the variance in progress between these classes, the data will be processed for normality, homogeneity, and hypothesis testing.

1) Normalized N-Gain Data Normality Test

The Kolmogorov-Smirnov and Shapiro-Wilk tests were employed to assess the normality of the normalized gain test for both the experimental and control groups, with a significance level set at 0.05. This data can be processed using IBM SPSS Statistics 26.0 software as shown in Table 6 below.

TABLE 6. Normalized N-Gain Normality Test Results

		Kolmogorov-Smirnov			Shapiro-Wilk		
	Test	Statistic	df	Sig.	Statistic	df	Sig
Grade	Experiment	0.171	32	0.019	0.798	32	0.000
	Kontrol	0.115	31	0.200	0.976	31	0.707

In Table 6, the Kolmogorov-Smirnov significance value for the experimental class is 0.019. The normality test criteria dictate that data is considered normally distributed if the significance value is greater than 0.05; otherwise, it is not. Given that the experimental class data has a significance value of less than 0.05, it does not meet the normal distribution requirements. Conversely, Table 6 indicates that the Kolmogorov-Smirnov significance value for the control class is 0.200, which is above 0.05, suggesting a normal distribution. Therefore, the control class data is normally distributed. The distribution of data for both classes is further illustrated in Figures 1 and 2, based on the Q-Q Plot graph.

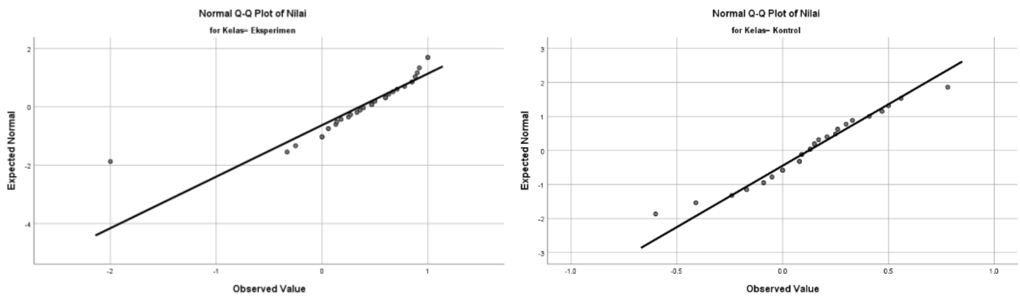

FIGURE 1. Normal Q-Q Plot of the Experimental Class and Figure 2 Normal Q-Q Plot of the Control Class

The lines on a Q-Q Plot show the expected pattern of a normal distribution, stretching from the bottom left corner to the top right corner. The variation of points around this line in the observed values illustrates how far the data differ from the expected normal distribution pattern. The expected values or those that fit the normal distribution are called Expected Normal and can be seen in Figure 1 and Figure 2. If the points closely follow the line, it suggests that the data is approximately normal. On the other hand, if the points are more dispersed from the line, it indicates that the data is likely not normal. In Figure 1, the experimental class data shows a deviation from the normal distribution, as many points are scattered away from the linear line. Conversely, Figure 2, which represents the control class, shows that most data points are closely aligned around the linear line, suggesting that the control class data is conforms to a normal distribution.

2) Normalized N-Gain Data Homogeneity Test

The next step is to carry out a homogeneity test or average difference test which can be seen in Table 7.

TABLE 7. Normalized N-Gain Homogeneity Test Results

Levene Statistic	df1	df2	Sig.
5.279	1	61	0.025

The significance value obtained helps assess the homogeneity of the data. A significance value greater than 0.05 indicates that the data is considered homogeneous, whereas a value less than 0.05 suggests that the data is inhomogeneous. According to Table 7, the significance value for both the experimental and control class data is 0.025, which is below 0.05, indicating that the data sets are not homogeneous.

3) Hypothesis Testing Normalized N-Gain Data

Before conducting hypothesis testing, it is essential to confirm the normality and homogeneity of the data. In this instance, the normalized gain data for the experimental group did not follow a normal distribution, while the data for the control group did. Additionally, a homogeneity test showed that neither the experimental nor the control group data met the homogeneity criteria. Due to these conditions not fulfilling the requirements for a T-test, the Mann-Whitney test was employed to assess the hypothesis regarding the normalized gain data for both groups.

Table 8 displays the outcomes of the hypothesis testing for the normalized gain scores from both the experimental and control groups, as analyzed using the Mann-Whitney test.

TABLE 8. Normalized N-Gain Hypothesis Test Results

Mann-Whitney U	285.500
Wilcoxon W	781.500
Z	-2.896
Asym. Sig. (2-tailed)	0.004

Table 8 shows that the significance value (2-tailed) is 0.004. The hypothesis testing decision is as follows: if the significance value (2-tailed) is greater than 0.05, then H_0 is accepted and H_1 is rejected; if the significance value (2-tailed) is less than 0.05, H_0 is rejected and H_1 is accepted. Since the significance value is 0.004, which is less than 0.05, H_0 is rejected and H_1 is accepted. Thus, it can be concluded that H_1 is supported, indicating a difference in the improvement of understanding mathematical concepts between the TGT instructional approach with the PhET application and the traditional learning model for third-grade elementary school students. The improvement was better for the experimental class with an average of 0.3569. Other similar research also states that the TGT learning model can enhance the comprehension of mathematical concepts (Astriana et al., 2017, p. 31; Aulia & Handayani, 2018, p. 120; Royani & Kelana, 2022, p. 19).

This is something that usually happens if the increase in students' ability to understand mathematical concepts through the TGT instructional approach supported by the PhET application is higher than that of students taught using the traditional instructional approach because the TGT instructional approach is supported by the PhET application Directing students in game sessions to discover concepts, to encourage students to engage with mathematics. This is in line with Asih, p. (2017, p. 180) that student engagement has increased significantly and their learning motivation has also increased as expected. Apart from that, students in the game stage are also directed to carry out competitions between groups so that students are more challenged. This competition directs students to be active in groups, and learning becomes effective. This is in line with Yanti & Yhasmin, p. (2023, p. 67) that students' ability to collaborate during the learning process has increased.

CLOSING

Conclusion

The conclusion provides the implication that learning mathematics through the use of the TGT instructional approach supported by the PhET application can improve understanding of mathematical concepts, therefore it would be good for teachers to use the instructional approach in every lesson, especially the TGT learning model. According to the research outcomes, it can be determined that the normalized gain test for the experimental class indicates an improvement of 0.3569, which is considered to be of medium level, representing a 35.67% increase. Meanwhile, the results of the normalized gain test in the conventional class showed an increase of 0.1235 in the low category and the increase was 11.55%. Next, an n-gain hypothesis test was carried out with a significance obtained of 0.004. This indicates that there is a difference in the enhancement of students' understanding of mathematical concepts between those using the TGT instructional approach with the PhET application and those using the conventional model. Therefore, the TGT instructional approach with the PhET application is more effective in improving students' comprehension of mathematical concepts compared to traditional models.

The following suggestions stem from the conclusions drawn from the research outcomes and discussions in this study:

1. Teachers are encouraged to adopt a variety of learning models. One effective model that can be applied is the Team Games Tournament (TGT), which utilizes the PhET application. This model promotes engaging activities that can reduce boredom, improve student understanding, and encourage teamwork. This is especially important in competitive environments, as it focuses on games and tournaments.
2. In future studies, it is recommended that educators utilize media-based learning applications like PhET. Thus, the results of this research should be followed up on to improve the overall effectiveness of the educational process.

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