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From Boredom to Brilliance: Using TGT and Physics Ludo to Teach Newton's Laws

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Abstract – *This study investigated the effectiveness of the cooperative learning model Teams Games Tournament (TGT) assisted by Physics Ludo media in enhancing students' understanding of Newton's laws of gravity. Conducted at SMA Negeri 14 Bekasi City, the research involved an experimental group (grade 10 Science 1) using the TGT model and a control group (grade 10 Science 3) following conventional teaching methods. Pretest and posttest scores were analyzed using the Wilcoxon Signed-Rank test, independent samples t-test, and Mann-Whitney U test to determine the impact of the intervention. The results revealed that both the experimental group (Wilcoxon Signed-Rank test, $p = 5.82\times10^{-11}$) and the control group ($p = 5.26\times10^{-8}$) showed significant improvements in posttest scores compared to their pretest scores. Additionally, an Independent Samples t-Test indicated that the experimental group scored significantly higher than the control group in the posttest ($t = 10.80$, $p = 2.16\times10^{-16}$). The Mann-Whitney U Test further demonstrated that the experimental group had greater improvement scores than the control group ($U = 1225.0$, $p = 4.79\times10^{-13}$). These statistical findings confirm the effectiveness of the TGT model with Physics Ludo. Moreover, survey feedback showed high levels of student engagement and motivation, with the majority finding the learning approach engaging and beneficial for understanding physics concepts. These findings highlighted the potential of game-based cooperative learning models to transform traditional educational practices, suggesting that further research and broader application could lead to enhanced learning outcomes in various subjects.*

Keywords: *cooperative learning; game-based learning; physics education; teams games tournament; student engagemen*

I. INTRODUCTION

Physics education plays a critical role in preparing students for scientific and technological advancements (Huang et al., 2015; Robertson et al., 2019). Understanding and excelling in physics is crucial for fostering future scientists, engineers, and informed citizens who can contribute to and benefit from technological progress. Therefore, it is essential to improve the quality of physics education to ensure students are well-equipped with the necessary knowledge and skills.

However, in Indonesian high schools, student performance in physics has been persistently low. Analysis of national exam results indicates that only 20% of students achieve high learning outcomes, with a significant majority (44%) performing at low levels (Nurnaifah et al., 2022). This trend highlights a significant challenge in the current education system, where traditional teaching methods are failing to effectively engage students and convey complex physics concepts.

Several factors contribute to the low performance in physics. Traditional teaching methods, which rely heavily on lectures and rote memorization, fail to engage students and make abstract concepts accessible (Clarke et al., 1989). Observations and preliminary studies reveal that a significant proportion of students find physics lessons monotonous and difficult to relate to real-world phenomena (Abdul-Razzaq & Bushey, 2009), leading to a lack of interest and motivation (Tambunan & Sihite, 2019). Specifically, at SMA Negeri 14 Bekasi, it was observed that teachers predominantly use lecture-based methods and lack creativity in presenting material, causing students to feel bored and uncomfortable during lessons. Supporting this, preliminary data showed that 55.4% of students are not interested in physics, and 77.7% lack enthusiasm when learning physics in the classroom. Additionally, students reported significant difficulties in understanding Newton's law of gravitation. This research focuses on addressing these specific issues to improve student engagement and understanding in physics.

Innovative educational strategies, such as game-based learning, have shown promise in enhancing student engagement and understanding (Azizah et al., 2021; Whitton, 2011). Game-based learning leverages the principles of play to create an interactive and stimulating learning environment. It transforms abstract concepts into tangible experiences, making learning more relatable and enjoyable. The Teams Games Tournament (TGT) model, combined with Physics Ludo, is a notable example of such an approach (Desky et al., 2022). These strategies provide a platform for students to support each other, thereby enhancing their collective understanding and performance (Patil et al., 2023; Tawil & Said, 2022).

Despite the promising results of game-based learning and cooperative strategies, there is still a need for more targeted research to determine their effectiveness in specific areas of physics education. The application of the Teams Games Tournament (TGT) model, assisted by Physics Ludo, in teaching Newton's laws of gravity represents a gap in current research. While existing studies have demonstrated the benefits of these methods in general, their impact on students' understanding of Newtonian physics and related concepts has not been thoroughly explored (Yuberti et al., 2020). This gap underscores the need for further investigation to validate and refine these innovative approaches.

This study aims to investigate the effectiveness of the cooperative learning model, Teams Games Tournament (TGT), assisted by Physics Ludo media, in improving students' learning outcomes on Newton's laws of gravity. By integrating game-based learning with cooperative strategies, this research seeks to address the challenges faced in physics education and enhance students' engagement and achievement. The primary research questions are: How does the TGT model, combined with Physics Ludo, impact students' understanding of Newton's laws? What level of motivation and interest can be observed as a result of implementing these methods? The findings of this study are expected to contribute to the development of more effective teaching practices, ultimately leading to better educational outcomes in physics.

II. METHODS

The study was conducted at SMA Negeri 14 Bekasi City, involving students from classes grade 10 Science during the second semester of the 2023-2024 academic year. The research employed a quasi-experimental design, specifically the Nonequivalent Control Group Design as shown in table 1 (Shadish & Luellen, 2012). The experimental group (grade 10 Science 1) received treatment (X_1) using Teams Games Tournament assisted by Physics Ludo media, while the control group (grade 10 Science 3) followed conventional teaching methods (X_2). Both groups were administered pretests (O_1) before the intervention and posttests (O_2) after the intervention to measure learning outcomes.

Table 1. Nonequivalent control group design

Pretest	Treatment	Posttest
O_1	X_1	O_2
O_1	X_2	O_2

The study focused on two main variables: the independent variable (Teams Games Tournament assisted by Physics Ludo) and the dependent variable (students' learning outcomes). The research procedure was divided into three phases: initial, implementation, and final as shown in figure 1. The initial phase involved problem formulation, preliminary study, creation of learning media, and development and validation of test and non-test instruments. The implementation phase included administering pretests, applying the intervention, conducting posttests, and collecting student responses via questionnaires. The final phase focused on data analysis and hypothesis testing.

The population comprised all students of SMA Negeri 14 Bekasi City, with samples selected using purposive sampling from classes grade 10 Science 1 and 10 Science 3, 35 students each. Data collection methods included objective tests to assess learning outcomes and questionnaires to gauge students' responses to the intervention.

Instrument validation involved content validity assessed by experts, reliability testing using K-R methods, and ensuring a balanced mix of question difficulty levels and discrimination indices.

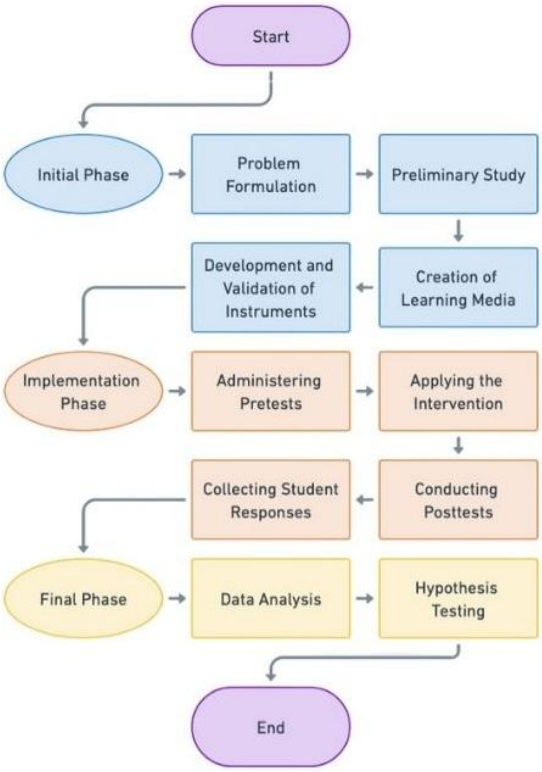

Figure 1. Research procedure

Data analysis included prerequisite tests for normality and homogeneity to determine the appropriate statistical tests. Normality tests using the Shapiro-Wilk method indicated that the pretest scores for both groups were not normally distributed, while the posttest scores were. Levene's test for homogeneity of variances showed that the variances were equal for posttest scores (Hsu, 2005). Based on these results, hypothesis testing utilized the Wilcoxon Signed-Rank test for pretest and posttest comparisons within each group due to the non-normal distribution of pretest scores, and independent samples t-tests for comparing posttest scores between the experimental and control groups. Additionally, the Mann-Whitney U test was used to further validate the differences in improvement scores between the groups.

To analyze the survey data, the questions were first categorized into three themes: Interest and Engagement, Effectiveness and Understanding, and Motivation. The percentage distribution of responses for each category was calculated, reflecting the proportions of students who selected each response option. Bar charts were created for each category to visually represent these distributions, ensuring consistent coloring for clarity. This process allowed for a clear and concise visualization of the survey results, facilitating an effective interpretation of student perceptions and attitudes towards the cooperative learning model using Physics Ludo.

III. RESULTS AND DISCUSSION

Table 2 provides a comprehensive overview of the statistical results, including the assumption tests for normality (Shapiro-Wilk Test) and homogeneity of variances (Levene's Test), as well as the main statistical tests performed, with corresponding statistics, p-values, and interpretations.

Table 2. Comprehensive statistical results

Category		Control	Experimental	p-value
Pretest	Mean	34.97	24.34	
	SD	19.63	9.49	
	Shapiro-Wilk Test	0.843	0.935	
	p-value[a]	0.00016	0.039	
	Levene's Test	4.393		0.040
Posttest	Mean	54.46	76.94	
	SD	7.66	9.65	
	Shapiro-Wilk Test	0.947	0.954	
	p-value[a]	0.089	0.153	
	Levene's Test	1.389		0.243
	Independent Samples t-Test	10.80		2.16×10^{-16}
Wilcoxon Signed-Rank Test		25.0	0.0	
	p-value[b]	5.26×10^{-8}	5.82×10^{-11}	
Mann-Whitney U Test		1225.0		4.79×10^{-13}

[a] p-value of Shapiro-Wilk Normality test, $\alpha = 0.05$
[b] p-value of statistical test of Wilcoxon Signed-Rank Test, $\alpha = 0.05$

The descriptive statistics reveal a notable improvement in scores from pretest to posttest for both groups. In the experimental group, the mean pretest score was 24.34 with a standard deviation of 9.49, which increased to a mean posttest score of 76.94 with a standard deviation of 9.65. The control group also exhibited improvement, with mean scores rising from 34.97 (SD = 19.63) in the pretest to 54.46 (SD = 7.66) in the posttest shown in figure 2. These descriptive statistics suggest that both groups benefited from their respective interventions, with the experimental group showing a more substantial increase in mean scores.

To further understand the data, we conducted normality tests using the Shapiro-Wilk test. For the experimental group, the pretest scores had a statistic of 0.935 and a p-value of 0.039, indicating a deviation from normality. Conversely, the posttest scores in the experimental group showed a statistic of 0.954 and a p-value of 0.153, suggesting normal distribution. The control group exhibited similar patterns, with pretest scores showing a statistic of 0.843 and a p-value of 0.00016, signifying non-normality, while the posttest scores had a statistic of 0.947 and a p-value of 0.089, indicating normality. These results highlight that the pretest scores for both groups do not follow a normal distribution, whereas the posttest scores do, allowing for the application of parametric tests on the posttest data.

The homogeneity of variances was assessed using Levene's test. For the pretest scores, the test yielded a statistic of 4.393 with a p-value of 0.040, indicating significantly different variances between the groups. However, for the posttest scores, the test resulted in a statistic of 1.389 and a p-value of 0.243, suggesting equal variances between the groups. This outcome necessitated the use of non-parametric tests for the pretest scores due to unequal variances but validated the use of parametric tests for the posttest scores due to equal variances.

We conducted Wilcoxon Signed-Rank tests to compare pretest and posttest scores within each group. The experimental group showed a statistic of 0.0 with a p-value of 5.82×10^{-11}, indicating a significant improvement. Similarly, the control group exhibited a statistic of 25.0 with a p-value of 5.26×10^{-8}, also indicating significant improvement. These findings confirm the effectiveness of the interventions in both groups.

An Independent Samples t-Test was performed to compare the posttest scores between the experimental and control groups. The test yielded a statistic of 10.80 with a p-value of 2.16×10^{-16}, indicating a significant difference in posttest scores. This result suggests that the experimental intervention was more effective than the control intervention.

Lastly, the Mann-Whitney U Test was used to compare the improvement scores between the experimental and control groups. The test showed a statistic of 1225.0 with a p-value of 4.79×10^{-13}, indicating a significant difference in improvement scores. This result highlights that the experimental group exhibited greater improvement compared to the control group as shown in figure 3.

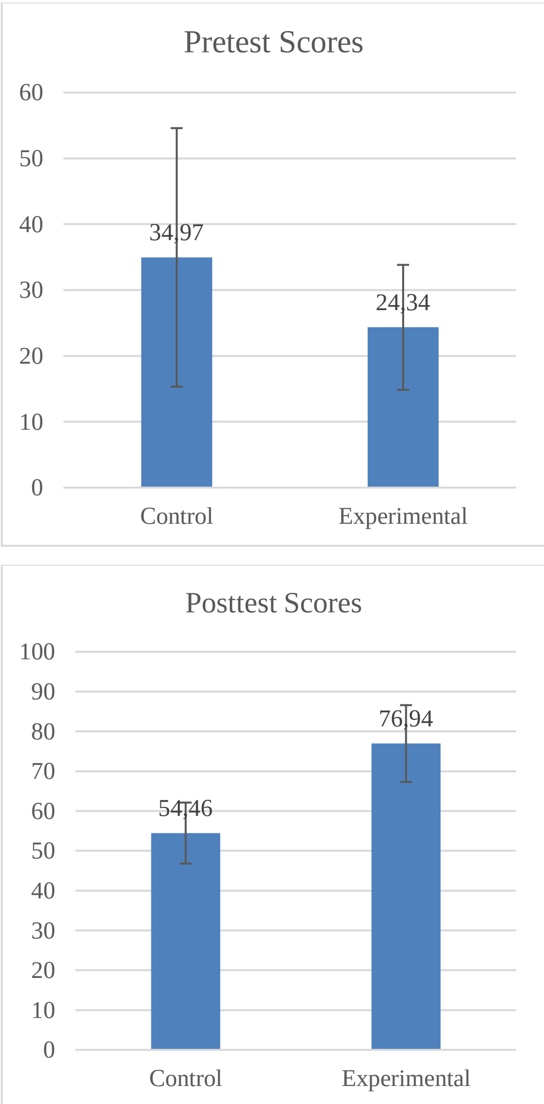

Figure 2. Pretest (top) and Posttest (bottom) scores of control and experimental groups.

The survey results show a notable level of engagement and interest among students in the cooperative learning model using Physics Ludo for studying Newton's law of gravitation as shown in table 3. A majority of students, about 67.85%, either agreed or strongly agreed that they found this learning approach engaging and interesting as shown in figure 4. A significant portion of students, 47.14%, agreed, while 20.71% strongly agreed with this sentiment. However, 30.71% of the students remained neutral, indicating a moderate level of indifference towards the model's engagement potential. Only a small fraction, 5.71%, strongly disagreed, suggesting minimal disengagement among the participants.

Table 3. Percentage distribution of survey

Response	1(%)	3(%)	4(%)	5(%)
Interest and Engagement	5.71	30.71	47.14	20.71
Effectiveness and Understanding	0	24.08	39.59	36.33
Motivation	0	5.71	36.33	48.57

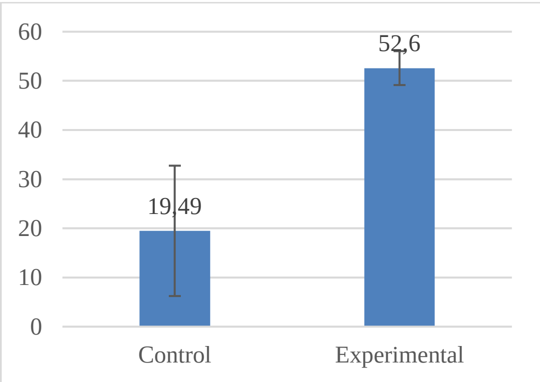

Figure 3. Improvement scores of control and experimental groups.

Regarding the effectiveness and understanding of the material, the cooperative learning model received positive feedback from the students. Approximately 75.92% of the students perceived the model as effective in enhancing their understanding of Newton's law of gravitation as shown in figure 5. Of these, 39.59% agreed and 36.33% strongly agreed that the model was beneficial for their learning. A smaller group, 24.08%, expressed neutrality, reflecting some uncertainty about its effectiveness. Notably, there were no strong disagreements, indicating a general absence of negative perceptions about the model's educational value.

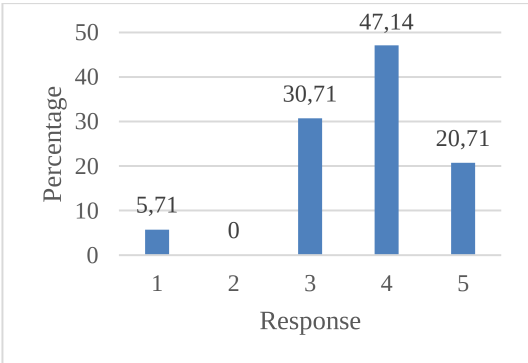

Figure 4. Percentage distribution for interest and engagement.

The cooperative learning model using Physics Ludo also appeared to significantly boost students' motivation to learn physics as shown in figure 6. A substantial majority of students, 94.28%, reported increased motivation, with 45.71% agreeing and 48.57% strongly agreeing that the model made them more enthusiastic about learning physics. A small percentage, 5.71%, remained neutral, indicating neither a positive nor negative impact on their motivation.

The significant improvement in posttest scores observed in the experimental group using the Teams Games Tournament (TGT) model with Physics Ludo media aligns closely with findings from prior research on game-based learning (Nadrah et al., 2017). Studies by Maryam (2018) have consistently shown that cooperative learning models like TGT enhance student achievement by fostering engagement and active participation. This is mirrored in our study, where the interactive and competitive elements of Physics Ludo transformed the learning experience, making Newton's laws of gravity more accessible and comprehensible for students.

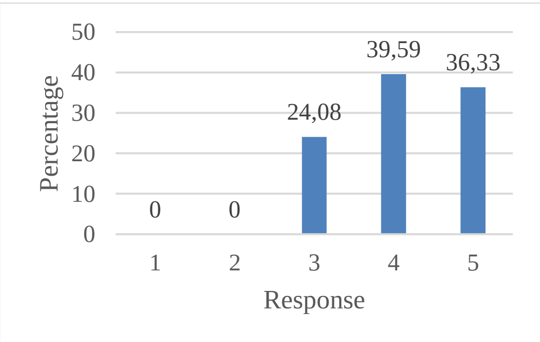

Figure 5. Percentage distribution for effectiveness and understanding

Moreover, the high levels of engagement and motivation reported by students in our survey are a testament to the power of game-based learning. The majority of students, around 67.85%, found the learning approach engaging and interesting. This echoes the findings of Apostol et al. (2013), who noted that gamification in education significantly boosts student motivation and cultivates a positive attitude towards learning. The enthusiasm and interest sparked by Physics Ludo are further supported by Charles et al. (2011); Yang (2017), whose research demonstrated that game-based environments provide immediate feedback and a sense of achievement, crucial for maintaining student interest and motivation.

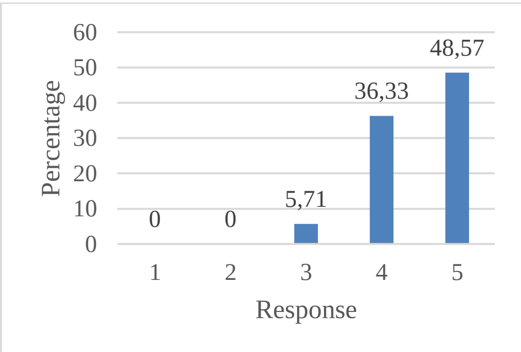

Figure 6. Percentage distribution for motivation

Our findings on the improved understanding of Newton's laws of gravity are particularly compelling. Highlighted that well-designed educational games have the unique ability to make abstract concepts more concrete and understandable (Linden & Joolingen, 2016; White, 1984). By turning theoretical knowledge into interactive and visually engaging experiences, Physics Ludo helped students visualize and internalize complex ideas. This approach is validated by the research of Linden & Joolingen (2016);

Vos et al. (2011), which found that game-based learning leads to deeper understanding and retention of subject matter compared to traditional methods.

The Wilcoxon Signed-Rank test results within the experimental group further underscore the effectiveness of the TGT model with Physics Ludo. The statistically significant improvement from pretest to posttest demonstrates that this innovative approach not only engages students but also enhances their academic performance. These results are in harmony with the work of Intan and Rowe, who observed similar benefits of cooperative learning models in improving students' grasp of physics concepts (Intan et al., 2019; Rowe et al., 2017).

The comparison of posttest scores between the experimental and control groups using the independent samples t-test revealed a substantial difference, favoring the experimental group. This significant outcome underscores the superior efficacy of the TGT model with Physics Ludo over conventional teaching methods. This finding is consistent with Harahap and Rahayu's studies, which showed that cooperative learning models significantly outperform traditional instructional strategies in fostering student achievement (Rahayu & Nugraha, 2018; Sitanggang & Harahap, 2013).

Interestingly, the Mann-Whitney U test results for improvement scores provide further validation. The significant difference in improvement scores between the groups indicates that the TGT model with Physics Ludo is particularly effective in facilitating academic progress. This is crucial, as it suggests that game-based cooperative learning not only enhances immediate learning outcomes but also contributes to sustained academic growth (Pratiwi & Muharini, 2010).

While our study highlights the numerous benefits of the TGT model with Physics Ludo, it is essential to acknowledge potential limitations. The non-randomized selection of participants and the specific context of SMA *Negeri* 14 Bekasi City might limit the generalizability of the findings. However, these results provide a strong foundation for future research and practical applications in diverse educational settings.

Looking ahead, future research should explore the long-term impact of game-based cooperative learning on student outcomes. Longitudinal studies could provide insights into whether the observed improvements in understanding and motivation persist over time. Additionally, expanding this research to other subjects and educational levels could reveal broader applications of the TGT model with Physics Ludo.

IV. CONCLUSION AND SUGGESTION

The research conducted at SMA Negeri 14 Bekasi City demonstrated the effectiveness of the cooperative learning model Teams Games Tournament (TGT) assisted by Physics Ludo media in teaching Newton's laws of gravity. Through rigorous statistical analysis, including the Wilcoxon Signed-Rank test, independent samples t-test, and Mann-Whitney U test, the study showed significant improvements in students' posttest scores in the experimental group compared to the control group. Additionally, the survey results indicated high levels of student engagement and motivation with the game-based learning approach. These findings suggest that the TGT model with Physics Ludo not only enhances academic performance but also fosters a more interactive and enjoyable learning environment.

Consequently, this innovative educational strategy holds great promise for improving physics education and potentially other subjects, warranting further research and wider implementation in diverse educational settings. Future studies should explore the long-term effects of this model on student learning outcomes and investigate its applicability across different age groups and academic disciplines. Educators are encouraged to integrate game-based learning tools like Physics Ludo into their teaching practices to create more engaging and effective learning experiences. Moreover, professional development programs should be designed to train teachers in implementing such interactive learning models, ensuring that students benefit fully from these innovative educational strategies.

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