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Promoting higher-order thinking skills and learning motivation through the teams games tournaments learning model in physics education: A Rasch model analysis

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ABSTRACT

This study aims to analyze the impact of implementing the Teams Games Tournaments (TGT) learning model on students' Higher-order Thinking Skills (HOTS) and learning motivation in the context of Global Warming. The research employed a quantitative approach, involving 44 eleventh-grade high school students as participants. Data analysis using the stacking test indicated an average logit increase of 1.40 for HOTS and 1.98 for learning motivation. The effect size analysis revealed a large category (1.63) for HOTS and a medium category (0.59) for learning motivation. Additionally, the implementation of the TGT model achieved an average score of 90% in learning quality assessments, accompanied by highly positive student responses. These findings indicate that the TGT learning model is effective in enhancing students' HOTS and learning motivation, particularly for complex physics topics such as Global Warming. The implications of this study suggest that the TGT model can serve as an innovative pedagogical strategy to foster a dynamic learning environment, support better academic achievement, and increase students' enthusiasm for learning.

Meningkatkan higher-order thinking skills *dan motivasi belajar melalui model pembelajaran* teams games tournaments *dalam pendidikan fisika: Analisis model Rasch*

Kata Kunci:

higher-order thinking skills, *motivasi belajar, pendidikan fisika, analisis model Rasch,* teams games tournaments

ABSTRAK

Penelitian ini bertujuan untuk menganalisis pengaruh penerapan model pembelajaran Teams Games Tournaments *(TGT) terhadap* Higher-order Thinking Skills *(HOTS) dan motivasi belajar siswa pada materi Pemanasan Global. Penelitian menggunakan pendekatan kuantitatif dengan melibatkan 44 siswa kelas XI SMA sebagai partisipan. Analisis data menggunakan uji stacking menunjukkan peningkatan rata-rata logit sebesar 1,40 untuk HOTS dan 1,98 untuk motivasi belajar. Hasil analisis* effect size *menunjukkan kategori besar (1,63) untuk HOTS dan kategori sedang (0,59) untuk motivasi belajar. Selain itu, implementasi model TGT memperoleh skor rata-rata 90% dalam penilaian kualitas pembelajaran, dengan respons siswa yang sangat positif. Temuan ini mengindikasikan bahwa model pembelajaran TGT efektif dalam meningkatkan HOTS dan motivasi belajar siswa, khususnya pada materi fisika yang bersifat kompleks seperti Pemanasan Global. Implikasi dari penelitian ini adalah bahwa model pembelajaran TGT dapat menjadi strategi pedagogis yang* *inovatif untuk menciptakan suasana pembelajaran yang dinamis, mendukung pencapaian hasil akademik yang lebih baik, serta meningkatkan antusiasme siswa dalam pembelajaran.*

Contribution to the literature

This research contributes to:

- This study provides valuable insights into how gamified, competitive, and cooperative learning models can encourage student engagement in learning activities and promote HOTS.
- This study offers evidence for TGT's benefits in education, supporting curriculum design, teaching strategies, and assessments to promote HOTS and learning motivation in the context of global warming.
- This study serves as a foundation for further exploration across various physics topics and their impact on other students' cognitive and affective dimensions.

1. INTRODUCTION

The goal of education should not only focus on knowledge transfer but also attempt to balance knowledge acquisition with the development of essential skills, particularly higher-order thinking and reasoning skills [1], [2]. Nowadays, the thinking skills that a person really needs to be able to adapt and face challenges in the 21st century are HOTS. HOTS is a complex thinking skill that encompasses cognitive skills to comprehend, analyze, and process information to solve problems [3]. HOTS development plays a vital role in supporting students' skills to think logically, critically, and innovatively, besides analyzing various issues from several perspectives comprehensively to encourage a strong sense of self-confidence in schools [4]. The emphasis on HOTS has intensified in 21st-century education, as they are crucial for equipping students to tackle real-world challenges. HOTS includes the skills to comprehend, analyze, evaluate, and create solutions, which are crucial for addressing intricate challenges, including worldwide concerns like global warming and climate change. Nonetheless, numerous studies suggest that high school students, particularly in the context of physics education, continue to demonstrate low levels of HOTS. For instance, the research by Mahmudah *et al.* [5] showed that the HOTS of high school students, especially for physics, is still low. Other than that, the research by Fajriyah and Agustini stated that the level of student achievement for each indicator of HOTS remains low [6]. Learning media, teacher's teaching methods, and internal students have an impact on high or low levels of higher-order thinking skills [6], [5]. The insufficient development of HOTS adversely affects students' capacity for critical, logical, and innovative thought processes. Indeed, the development of HOTS is shaped by a range of influences, including the types of learning media, teaching methods or models, and internal students, which have an impact on high or low levels of HOTS [5], [6].

Furthermore, one significant internal factor affecting HOTS development is student motivation. Learning motivation has an important role in optimizing student's learning process [7]. Sardiman [8] stated that student learning motivation is the mindset of all students who attempt to learn activities, ensure continuity, and provide direction so that set goals can be achieved. The research conducted by Santosa and Us [9] revealed that student learning motivation remains low, which is only 47.60%. One of the causes contributing to low learning motivation is the overuse of lecture methods in the learning process, which is teacher-centered. As a result, students are merely passive listeners, not actively engaged in the learning process [9]. Therefore, implementing innovative and interactive learning models is essential to foster active student participation and enhance learning outcomes.

An alternative solution that can be used to get over these problems is to implement an effective learning model that focuses on promoting HOTS and student learning motivation. One of the models that can be employed is a cooperative learning model, which emphasizes active student engagement and the teacher's role as a facilitator in assisting students to gain deeper knowledge [10]. Furthermore, the global warming topic in physics is an example of a complex issue that is relevant to the real world and allows students to practice HOTS. This material is designed to enhance students' analytical skills to solve contextual problems, starting from understanding the root cause, formulating solutions, data analysis, and then evaluating the effectiveness of implemented solutions [11].

Recent literature highlights the pressing necessity for the adoption of effective learning models to enhance students' HOTS, particularly in response to the challenges posed by modern education. As interest in HOTS within physics education increases, further research is needed to explore the effectiveness of cooperative learning models in broader contexts and across different subjects. In this context, the cooperative learning model, particularly the TGT, offers a promising approach to address this issue by increasing student engagement and facilitating the development of HOTS, which is essential for addressing the challenges of the 21st century. The TGT model integrates aspects of competition and collaboration, enhancing student learning motivation and promoting a deeper understanding of worldwide issues such as global warming and climate change through active engagement [12].

TGT learning model is part of cooperative learning that combines elements of games and competition in the form of group tournaments to increase the active participation of all students in the learning process [13]. The implementation of the TGT cooperative learning model has been demonstrated to improve social skills, interaction, and active student participation in a fun learning process, along with facilitating HOTS development for all students [14]. Based on Pratama and Purnomo's research [15], the application of TGT can train students to compete with HOTS, and there is a difference of 49% in the improvement of HOTS between the control class and the experimental class or class that is given the application of the TGT learning model. In addition, research conducted by Rati [16] also showed that the TGT-type cooperative learning model affects HOTS and student learning motivation. TGT-type cooperative learning, in which there are games, can make students more active and prevent them from getting bored quickly during physics lessons. TGT is able to stimulate better teaching and learning interaction, and this model is also able to improve learning quality, especially learning outcomes [17]. This learning model is oriented towards individual work in groups. This means that each individual is responsible for understanding the concept with the help of group members who have been formed so that it can increase student learning motivation [18].

In fact, previous studies have highlighted various learning strategies and models aimed at enhancing student engagement and cognitive skills. For instance, the influence of the TGT method on HOTS [14],[16], cooperative learning for self-strengthening and motivation [17], and several studies have investigated the effects of cooperative learning or problem-based learning models on improving students' learning motivation and HOTS [19]. However, research specifically focusing on the effects of the TGT model in physics education, particularly its impact on HOTS and learning motivation, remains limited, particularly in the context of contemporary issues such as global warming. Therefore, this study intends to fill this gap by investigating the effectiveness of the TGT learning model on students' learning motivation and HOTS in the context of global warming. This will offer empirical evidence to comprehend how real-world contexts can be incorporated into cooperative learning models, enhancing the relevance and meaningful learning experiences for students, as well as improving their thinking skills, thus creating opportunities for further research that can bridge the disciplines of physics and environmental concerns.

Thus, the rationale behind this study stems from the low levels of HOTS and learning motivation observed among students, particularly in the context of physics learning. Given the critical importance of HOTS in fostering analytical and problem-solving skills, especially when students are confronted with complex scientific concepts, such as global warming, enhancing critical thinking skills that go beyond basic understanding has become an urgent priority. Consequently, it is essential to investigate learning models that not only increase students' motivation to learn physics but also effectively develop their HOTS. TGT is a promising model that offers an interactive approach to actively engage students, enhance their motivation in learning physics, and deepen their understanding of HOTS. Therefore, the main purpose of this study is to investigate the effectiveness of the TGT learning model in enhancing students' HOTS (in the areas of analysis, evaluation, and creation) and learning motivation, filling the identified research gaps in the existing literature. Ultimately, this research seeks to contribute valuable insights into best practices for educators, highlighting the necessity of fostering student HOTS to equip them for future challenges.

2. METHOD

This study employed quantitative research with a pre-experimental design and a one-group pretest-posttest model. The treatment results can be determined by comparing the before and after situations in which the TGT cooperative learning model was implemented. After receiving athics approval, the research was conducted. The one-group pretest-posttest model is shown in Table 1. This design allows researchers to measure the direct impact of the intervention on the participants. Despite its limitations, the model provides valuable insights into changes resulting from the applied treatment.

Table 1. One Group Pretest-Posttest Model

Pretest	Treatment	Posttest
O_1	X	O_2

Information:
O_1 : A pre-test was administered before the TGT learning model was implemented
X : Treatment in the form of TGT Learning Model
O_2 : A posttest was administered after the TGT learning model was implemented

The hypothesis presented in this study is as follows:

H_{01} : The implementation of the TGT learning model does not significantly enhance students' HOTS in the context of global warming.

H_{02} : The implementation of the TGT learning model does not significantly enhance students' learning motivation in physics learning.

The research procedure consisted of three stages, namely the First stage, the implementation stage, and the last stage, as shown in Figure 1. Each stage was systematically designed to ensure the research objectives were achieved effectively. Data collection and analysis were conducted at each stage to monitor progress and validate findings. This structured approach ensured the reliability and accuracy of the results obtained in the study. The findings derived from this process provide a solid foundation for further research and practical applications.

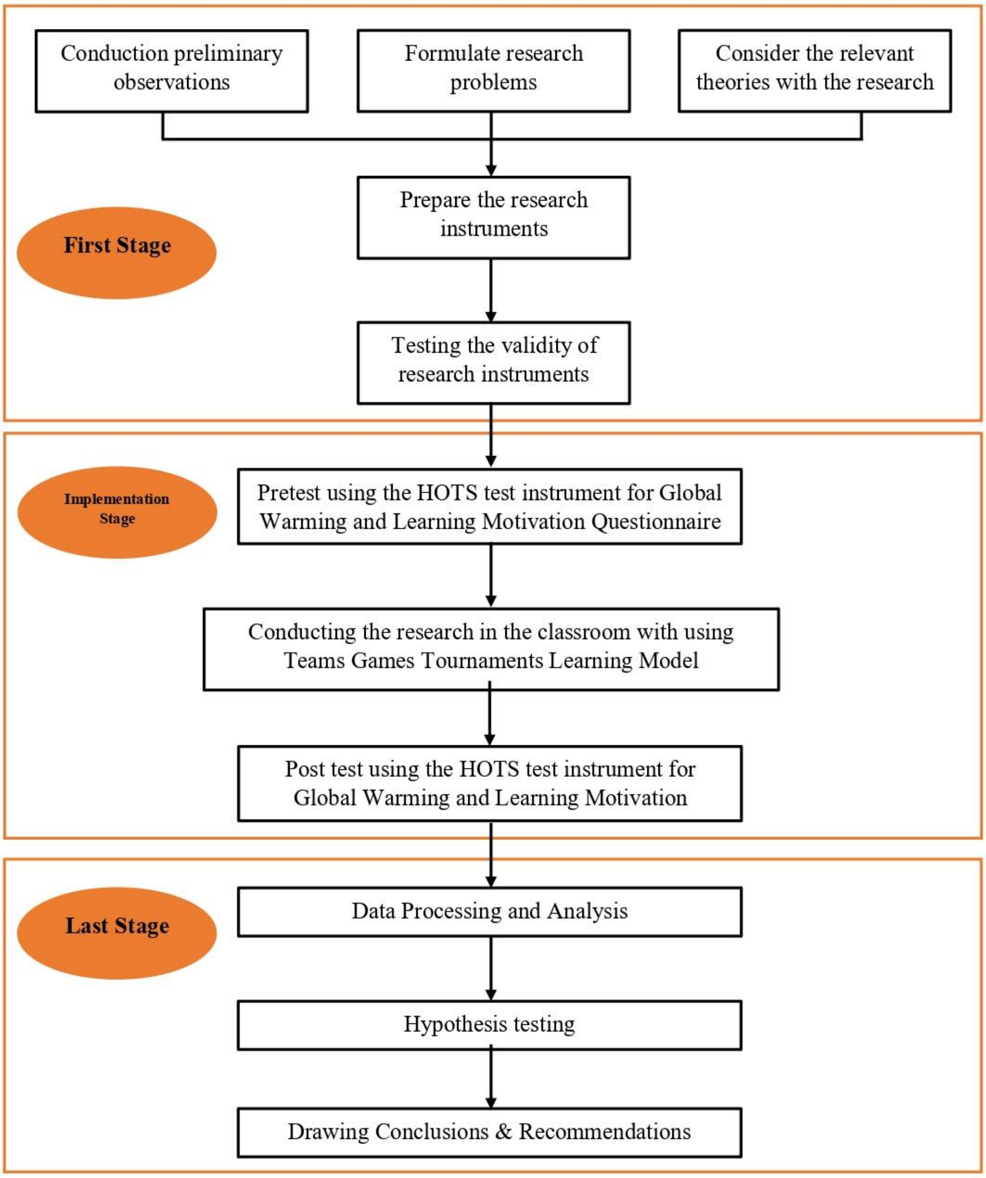

Figure 1. Flowchart of Research Procedures

This study involved 44 eleventh-grade students at one of the high schools in Bandung. After receiving consent from parents and students, the research was conducted. HOTS data were gathered using the HOTS test instrument for Global Warming material, which consists of ten two-tier multiple-choice questions. This test was utilized for both pretest and posttest. Figure 2 shows the results of the unidimensionality of the HOTS instrument obtained from the field trial and analyzed using the Rasch model.

Table of STANDARDIZED RESIDUAL variance in Eigenvalue units = Item information units

		Eigenvalue	Observed		Expected
Total raw variance in observations	=	22.3507	100.0%		100.0%
Raw variance explained by measures	=	7.3507	32.9%		33.6%
Raw variance explained by persons	=	3.1912	14.3%		14.6%
Raw Variance explained by items	=	4.1595	18.6%		19.0%
Raw unexplained variance (total)	=	15.0000	67.1%	100.0%	66.4%
Unexplained variance in 1st contrast	=	2.2979	10.3%	15.3%	
Unexplained variance in 2nd contrast	=	2.1974	9.8%	14.6%	
Unexplained variance in 3rd contrast	=	1.7724	7.9%	11.8%	
Unexplained variance in 4th contrast	=	1.4597	6.5%	9.7%	
Unexplained variance in 5th contrast	=	1.3232	5.9%	8.8%	

Figure 2. Results of HOTS Test Instrument for Global Warming Dimensionality

In Figure 2, it can be seen that the raw variance explained by the value of the measure obtained is 32.90%. According to Sumintono and Widhiarso [20], if the raw variance explained by the measured value is >20%, then the instrument used can measure one variable without being influenced by other variables. In addition to the raw variance explained by measures value, the unidimensionality of the instrument can also be seen from the unexplained variance value in 1st contrast. If the value is less than 15%, then the instrument has a good unidimensionality quantity [21]. The results obtained show the value of unexplained variance in 1st contrast of 10,30%, so it can be said that the quantity of unidimensionality of the HOTS Global Warming instrument is good, and overall, the instrument can be used to measure students' HOTS.

Then there is the value of item and person separation reliability, which shows the consistency of respondents' answers and the consistency of items that can provide credible results when used for measurement. To measure the reliability of the interaction between a person and the item as a whole, the Cronbach alpha value is used [22]. Figure 3 shows the results of item and person reliability and Cronbach alpha of the HOTS Global Warming instrument.

```
-------------------------------------------------------------------------------
|          TOTAL                         MODEL         INFIT        OUTFIT    |
|          SCORE      COUNT     MEASURE   S.E.       MNSQ   ZSTD   MNSQ   ZSTD |
|-----------------------------------------------------------------------------|
| MEAN       7.8      15.0         .13    .64       1.00    .06    .92    .00 |
|  SEM        .4        .0         .17    .01        .04    .12    .06    .12 |
| P.SD       2.8        .0        1.11    .07        .23    .76    .35    .76 |
| S.SD       2.8        .0        1.12    .08        .23    .77    .36    .77 |
| MAX.      14.0      15.0        3.15   1.06       1.66   2.02   1.86   1.91 |
| MIN.       3.0      15.0       -1.77    .60        .62  -1.52    .45  -1.30 |
|-----------------------------------------------------------------------------|
| REAL RMSE    .67 TRUE SD     .88  SEPARATION  1.31  Person RELIABILITY  .63 |
|MODEL RMSE    .65 TRUE SD     .90  SEPARATION  1.39  Person RELIABILITY  .66 |
| S.E. OF Person MEAN = .17                                                   |
-------------------------------------------------------------------------------
Person RAW SCORE-TO-MEASURE CORRELATION = 1.00
CRONBACH ALPHA (KR-20) Person RAW SCORE "TEST" RELIABILITY = .66  SEM = 1.64
STANDARDIZED (50 ITEM) RELIABILITY = .87

     SUMMARY OF 15 MEASURED Item
-------------------------------------------------------------------------------
|          TOTAL                         MODEL         INFIT        OUTFIT    |
|          SCORE      COUNT     MEASURE   S.E.       MNSQ   ZSTD   MNSQ   ZSTD |
|-----------------------------------------------------------------------------|
| MEAN      21.7      42.0         .00    .38       1.01    .11    .92   -.11 |
|  SEM       2.5        .0         .32    .01        .02    .13    .03    .09 |
| P.SD       9.2        .0        1.18    .02        .09    .48    .13    .34 |
| S.SD       9.5        .0        1.22    .02        .10    .50    .13    .35 |
| MAX.      35.0      42.0        1.39    .44       1.19   1.06   1.06    .33 |
| MIN.      11.0      42.0       -1.82    .35        .87   -.52    .64   -.68 |
|-----------------------------------------------------------------------------|
| REAL RMSE    .39 TRUE SD    1.12  SEPARATION  2.87  Item   RELIABILITY  .89 |
|MODEL RMSE    .38 TRUE SD    1.12  SEPARATION  2.94  Item   RELIABILITY  .90 |
| S.E. OF Item MEAN = .32                                                     |
```

Figure 3. Results of Person Reliability, Item Reliability, and Cronbach Alpha

Based on Figure 3, it can be seen that person reliability is 0.63 with sufficient interpretation and item reliability is 0.89 with good interpretation. This shows that the consistency of students' answers is good, and the quality of the HOTS Global Warming instrument is good in terms of the consistency of the weight of the questions and answer choices. Then for the Cronbach's alpha (KR-20) value of 0.66 with a good interpretation. This shows that the SOWATT instrument has good quality because it can identify the relationship between students (person reliability) and items (item reliability) [23]. Based on the results of the analysis, it can be concluded that the HOTS Global Warming instrument is reliable for use in research.

Meanwhile, the Learning Motivation Questionnaire adapted from Natun [24] was used to measure student's learning motivation. The questionnaire consists of 20 items to measure eight indicators: perseverance in learning, resilience in facing difficulties, interest in learning, mindful opinion, not removing any pleasant things to find and solve problems, and high achievement in learning. The learning model implementation is measured by calculating the learning effectiveness value, and students' learning responses are obtained from student response questionnaire results.

The pretest and posttest data were then analyzed by employing the Rasch model analysis with Winsteps 4.5.0 software. The data analyzed through Rasch modeling includes the Wright map, which describes the distribution of student abilities and the level of difficulty of questions on the same scale [20]. In addition, the results of the Rasch model analysis are also used to convert raw data into the same interval scale (logit value) to provide precise and accurate measurements of individual student skill changes [25]. Thus, the logit values and the data gathered from the HOTS test and Learning Motivation Questionnaire can be used for further statistical analysis. The next analysis is a prerequisite test for the hypothesis test, which is carried out using the IBM SPSS Statistics v.26 software. The prerequisite test consists of normality and homogeneity tests. A normality test was conducted to determine whether the pretest and posttest data were normally distributed. The normality test used for this study is Saphiro-Wilk. The decision-making of normality tests is based on the following: (1) if the significance value (Sig.) is greater than 0.05, then the data is normally distributed; (2) if the significance value (Sig.) is smaller than 0.05, then the data is not normally distributed. Furthermore, the homogeneity test is carried out to determine whether there is data variance or not. The decision-making homogeneity test used is as follows: (1) if the significance value (Sig.) based on the mean is more than 0.05, then the data is homogeneous; (2) if the significance value (Sig.) based on the mean is less than 0.05, then the data is not homogeneous.

Furthermore, logit values are also used for stacking analysis. Stacking analysis in the Rasch model is a longitudinal analysis technique used to compare students' HOTS and learning motivation before and after the implementation of the TGT learning model. If students' HOTS increased significantly after implementing the TGT model, this demonstrates that the learning model was effective in improving students' HOTS and learning motivation [25].

The calculation of the learning effectiveness value is used to determine any changes that occur due to treatment by analyzing the difference size before and after the implementation of the TGT learning model. Based on the results of the effect size calculation, the effectiveness of implementing the TGT learning model in improving students' HOTS and learning motivation is examined. The equation employed refers to Cohen's d [26], as indicated in Equation 1.

$$d = \frac{|\bar{x}_{pretest} - \bar{x}_{posttest}|}{\sqrt{\frac{s^2{}_{pretest} + s^2{}_{posttest}}{2}}} \qquad (1)$$

Information:
$\bar{x}_{pretest}$: student pretest mean score
$\bar{x}_{posttest}$: student posttest mean score
$s^2{}_{pretest}$: student pretest variance results
$s^2{}_{posttest}$: student posttest variance results

The Cohen's d calculation results are interpreted based on Table 2 below.

Table 2. Interpretation of Cohen's d Values

Cohen's d values	Interpretation
$0.80 \leq d \leq 2.00$	Large
$0.50 \leq d < 0.80$	Currently
$0.20 \leq d < 0.50$	Small
$0.00 \leq d < 0.20$	Not enough

Further data analysis was carried out based on the observation results of classroom learning conducted by observers. This analysis is used to determine whether the TGT learning model is being implemented in the classroom as planned. The data obtained from the observation sheet is in the form of a numerical rating scale 1-4 and consists of 15 items. Then, the average observation value for each meeting will be determined so that it can be interpreted qualitatively. The equation used is shown in equation (2) as follows [27].

$$P = \frac{Total\ score}{Maximum\ score} x\ 100\% \qquad (2)$$

The data analysis results are interpreted based on the criteria shown in Table 3. These interpretations provide a clearer understanding of the trends and patterns observed in the study.

Table 3. Observation Criteria for Learning Implementation

Criteria (%)	Category
70 ≤ P < 90	Good
50 ≤ P < 70	Medium
30 ≤ P < 50	Low
0 ≤ P < 30	Very low

The next data analysis is to identify students' responses to implementing the TGT learning model on global warming material, which was gathered through student questionnaires. The questionnaire consists of 10 questions on a Likert scale of 1-4. The Likert scale categories and criteria used in this research are shown in Table 4.

Table 4. Observation Criteria for Learning Implementation

Category	Score	Criteria (%)
Strongly agree	4	0 ≤ P < 25
Agree	3	25 ≤ P < 50
Disagree	2	50 ≤ P < 75
Strongly disagree	1	75 ≤ P < 100

3. RESULTS AND DISCUSSION

Before we proceed to the discussion and result analysis, here is an overview of the operational procedures of the research that has been carried out. The study was conducted in several stages, starting from the preparation of research instruments, implementation of the learning model, data collection, and subsequent analysis. Each step was carefully designed to ensure the validity and reliability of the findings. The operational procedures adhered strictly to the research objectives, ensuring that the impact of the TGT model on HOTS and learning motivation could be accurately measured and analyzed.

Table 5. Storyboard of Research Procedure

No	Syntax	Research Procedure
1	Determining the learning purpose	Determining the learning purpose aims to improve students' HOTS and Learning Motivation on Global Warming material
2	Preparing the material	• Preparing HOTS-based student worksheets on Global Warming material • Preparing flashcards to be used during the TGT learning model • Preparing material for presentation
3	Determining the learning methods	The TGT learning model chose to facilitate students to be cooperative in the learning process to achieve the greatest achievement, specifically in the improvement of HOTS and Learning Motivation

4	Doing the learning methods	• Divide students into several tournament tables according to student abilities. • Each student represents each group to play a game using flashcards on the tournament table.  • Each student tries to get the highest points at each tournament table, and the group will be awarded if they have the highest points. 
5	Evaluating the learning process	Evaluate the learning process in Global Warming material using the HOTS test instrument and Learning Motivation Questionnaire.

The results of the initial analysis are depicted in the Wright map, which illustrates the distribution of students' abilities alongside the difficulty levels of the questions on the same scale. Figure 4 presents the Wright map derived from the posttest data of the HOTS test instrument for the topic of Global Warming. This visualization provides a clear comparison between student performance and the complexity of each question, offering valuable insights for further instructional improvements.

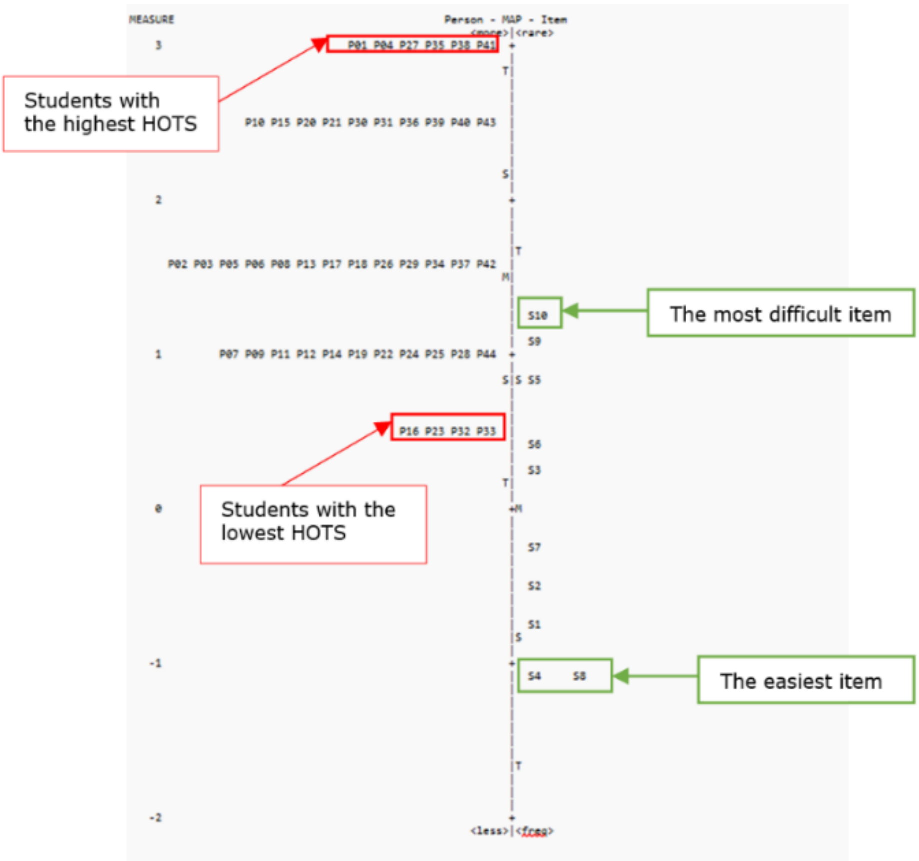

Figure 4. Wright Map of Person and Item of HOTS on Global Warming

Figure 4 displays the distribution of students' HOTS and the difficulty levels of HOTS questions. The Wright map on the left depicts students' abilities to solve these questions. Students coded P01, P04, P27, P35, P38, and P41 (six students) exhibit the highest proficiency in solving HOTS questions compared to others. Furthermore, these six students fall outside the two-standard deviation (T) limit, marking them as outliers with significantly higher intelligence. On the other hand, students coded P16, P23, P32, and P33 (four students) demonstrate the lowest ability to tackle HOTS questions. Regarding the distribution of item difficulty levels, the item coded S10 falls into the very difficult category, while the items coded S4 and S8 are in the very easy category. The Wright map for the Learning Motivation variable is shown in Figure 5 below.

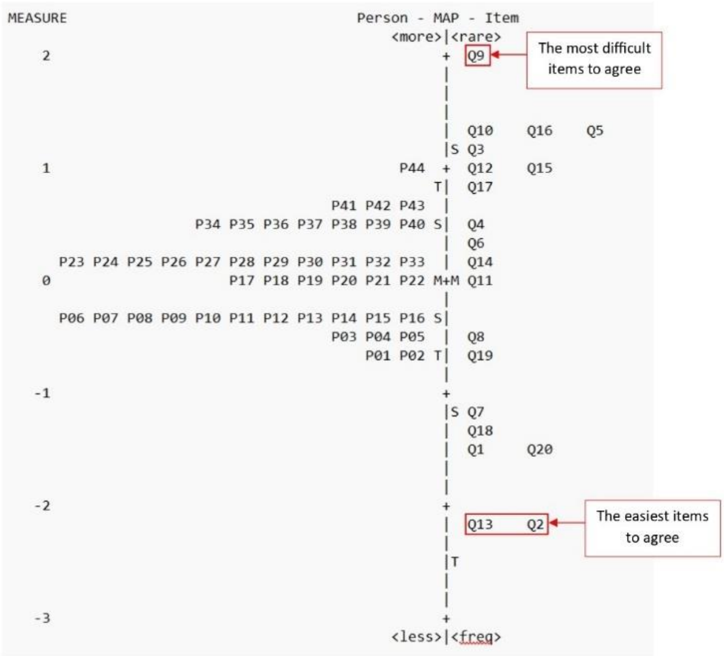

Figure 5. Wright Map of Person and Item Learning Motivation

Figure 5 shows the Wright map of persons and items based on the Learning Motivation Questionnaire results. The right side of the Wright map indicates that the question coded Q9 is the most difficult for students to agree with, while the questions coded Q13 and Q2 are the easiest for students to accept.

The pretest and posttest results were processed using statistical tests, which included prerequisite tests and hypothesis tests. Based on the data processing results of the pretest and posttest HOTS scores for Global Warming and the Learning Motivation Questionnaire using IBM SPSS Statistics v.26 software, the significance value for HOTS Global Warming is 0.08, and the significance value for the Learning Motivation Questionnaire is 0.09. According to these criteria, the data is normally distributed. For the homogeneity test, the significance value based on the mean for HOTS Global Warming is 0.89, and the significance value based on the mean for the Learning Motivation Questionnaire is 0.86. Therefore, based on these criteria, the data is homogeneously distributed.

The results of the prerequisite test processing show that the data is both normally distributed and homogeneous. Consequently, a parametric test, namely the paired sample t-test, can be used to test the hypothesis. The paired sample t-test aims to determine whether there is an average difference between two groups of paired samples. The paired sample t-test was conducted using SPSS v.26 software. The decision-making criteria are as follows: (1) if the significance value (2-tailed) is less than 0.05, then H_{01} and H_{02} are rejected; (2) if the significance value (2-tailed) is greater than 0.05, then H_{01} and H_{02} are accepted. The results of data processing for the paired sample t-test are shown in Table 6. These results provide statistical evidence to evaluate the effectiveness of the implemented intervention.

Table 6. Results of Paired Sample T-Test

Variable	Mean	Std. Deviation	Sig. (2-Tailed)
HOTS	-147.75	107.47	0.00
Learning Motivation	-153.73	87.54	0.00

Table 6 shows the results of the paired sample t-test for the variables of HOTS and learning motivation. The significance value (2-tailed) for both variables is 0.00, which is less than 0.05. Based on the decision-making criteria for the paired sample t-test, this indicates that H_{01} and H_{02} are rejected. The result shows that the TGT learning model improves students' HOTS and learning motivation.

This finding is in line with research conducted by Rahmat *et al.* [28], which shows that the implementation of the TGT-type cooperative learning model can improve students' HOTS on abstract material, such as global warming. Additionally, the application of the TGT-type cooperative learning model can increase students' learning motivation, as it allows students to learn in a more relaxed environment without feeling forced to participate in classroom learning activities [29]. These results are also supported by the stacking test analysis on the HOTS and learning motivation of each student, as shown in Table 7 below.

Table 7. Stacking Test Results of HOTS and Learning Motivation

HOTS				Learning Motivation			
Students' Code	Measure		Logit Improvement	Students' Code	Measure		Logit Improvement
	Pretest	Posttest			Pretest	Posttest	
P01	-0.01	3.78	3.79	P01	-1.87	-0.73	1.14
P02	1.53	1.59	0.06	P02	-2.57	-0.73	1.84
P03	0.45	1.59	1.14	P03	-1.87	-0.5	1.37
P04	1.53	3.78	2.25	P04	-1.87	-0.5	1.37
P05	-0.94	1.59	2.53	P05	-1.87	-0.5	1.37
P06	-0.01	1.59	1.60	P06	-2.8	-0.26	2.54
P07	0.45	0.98	0.53	P07	-1.16	-0.26	0.9
P08	-0.46	1.59	2.05	P08	-2.34	-0.26	2.08
P09	-0.94	0.98	1.92	P09	-2.1	-0.26	1.84
P10	0.94	2.47	1.53	P10	-0.93	-0.26	0.67
P11	0.45	0.98	0.53	P11	-1.16	-0.26	0.9
P12	-2.38	0.98	3.36	P12	-1.63	-0.26	1.37
P13	0.94	1.59	0.65	P13	-1.16	-0.26	0.9
P14	0.45	0.98	0.53	P14	-1.4	-0.26	1.14
P15	1.53	2.47	0.94	P15	-1.63	-0.26	1.37
P16	-1.53	0.47	2.00	P16	-1.4	-0.26	1.14
P17	-0.46	1.59	2.05	P17	-1.87	-0.03	1.84
P18	0.94	1.59	0.65	P18	-2.1	-0.03	2.07
P19	-0.94	0.98	1.92	P19	-1.63	-0.03	1.6
P20	-0.01	2.47	2.48	P20	-2.8	-0.03	2.77
P21	0.94	2.47	1.53	P21	-2.57	-0.03	2.54
P22	-0.46	0.98	1.44	P22	-1.87	-0.03	1.84
P23	-0.46	0.47	0.93	P23	-1.87	0.21	2.08
P24	0.94	0.98	0.04	P24	-1.87	0.21	2.08
P25	0.94	0.98	0.04	P25	-2.34	0.21	2.55
P26	-0.01	1.59	1.6	P26	-1.63	0.21	1.84
P27	3.70	3.78	0.08	P27	-1.87	0.21	2.08

P28	0.45	0.98	0.53	P28	-2.57	0.21	2.78
P29	0.45	1.59	1.14	P29	-1.87	0.21	2.08
P30	0.94	2.47	1.53	P30	-2.57	0.21	2.78
P31	-0.46	2.47	2.93	P31	-2.34	0.21	2.55
P32	-0.46	0.47	0.93	P32	-2.1	0.21	2.31
P33	-0.46	0.47	0.93	P33	-1.63	0.21	1.84
P34	1.53	1.59	0.06	P34	-1.63	0.46	2.09
P35	2.39	3.78	1.39	P35	-2.57	0.46	3.03
P36	0.45	2.47	2.02	P36	-1.87	0.46	2.33
P37	0.45	1.59	1.14	P37	-2.1	0.46	2.56
P38	2.39	3.78	1.39	P38	-1.87	0.46	2.33
P39	0.45	2.47	2.02	P39	-1.63	0.46	2.09
P40	2.39	2.47	0.08	P40	-1.87	0.46	2.33
P41	0.45	3.78	3.33	P41	-1.63	0.7	2.33
P42	-2.38	1.59	3.97	P42	-1.87	0.7	2.57
P43	2.39	2.47	0.08	P43	-2.1	0.7	2.8
P44	0.94	0.98	0.04	P44	-2.1	0.95	3.05
Mean	0.43	1.83	1.40	Mean	-1.92	0.06	1.98

Table 7 shows that there was an increase in students' HOTS (HOTS) and learning motivation after the TGT model was implemented in learning. The average high-level thinking skills of students during the pretest was 0.43 on the logit scale, and during the posttest, it was 1.83 on the logit scale. This shows an increase of 1.40 on the logit scale, indicating that the implementation of the TGT learning model can enhance students' HOTS. For the learning motivation variable, the average pretest score was -1.92 on the logit scale, and the posttest score was 0.06 on the logit scale. The results of the analysis showed an increase of 1.98 on the logit scale, which indicates that there was an increase in student learning motivation after the TGT learning model was implemented. The advantages of the TGT learning model include training students to think at a higher level and actively engaging them in learning, thereby improving students' learning outcomes and learning motivation [30], [31].

The results of the effect size analysis for HOTS and learning motivation data, which demonstrate the effectiveness of learning, are shown in Table 8 below.

Table 8. Results of Effect Size Calculation

Variable	Results	Mean ($\bar{x}$)	Varians (s^2)	Effect Size	Interpretation
HOTS	Pretest	0.43	1.47	1.63	Good
	Posttest	1.83	0.98		
Learning	Pretest	-1.92	0.19	0.59	Medium
Motivation	Posttest	0.06	0.16		

Table 8 shows an effect size value of 1.63 with a large interpretation for the HOTS variable and 0.59 with a medium interpretation for the learning motivation variable. This indicates that there are positive changes in students' HOTS and learning motivation due to the implementation of the TGT learning model. The results of this study align with research carried out by Toifur and Kurniawan [31] and Yuliawati [32], which demonstrate that the TGT learning model can promote student learning motivation and have a positive influence on students.

Table 9 below shows the results of the analysis related to the implementation of the TGT learning model, conducted by observers over three meetings. The data indicate consistent improvement in student engagement and participation throughout the observed sessions. These findings further support the effectiveness of the TGT model in creating an interactive and collaborative learning environment.

Table 9. Results of Paired Sample T-Test

Meetings	Score	Max. Score	Results (%)	Category
1	56	60	93	Very Good
2	54	60	90	Very Good
3	57	60	95	Very Good
Mean			90	Very Good

Table 9 shows that the average percentage of scores over the three meetings is 90%. Thus, it can be concluded that the implementation of the TGT learning model on global warming material is very well applied.

Furthermore, Table 10 shows the results of the student response questionnaire regarding the implementation of the TGT learning model on global warming material.

Table 10. Results of Student Responses

Number Of Items	Frequency				Percentage (%)			
	Strongly Agree	Agree	Disagree	Strongly Disagree	Strongly Agree	Agree	Disagree	Strongly Disagree
1	12	32	0	0	27,27	72,73	0	0
2	30	14	0	0	68,18	31,82	0	0
3	8	36	0	0	18,18	81,82	0	0
4	29	15	0	0	65,91	34,09	0	0
5	34	10	0	0	77,27	22,73	0	0
6	13	31	0	0	29,55	70,45	0	0
7	17	27	0	0	38,64	61,36	0	0
8	23	21	0	0	52,27	47,73	0	0
9	2	42	0	0	4,55	95,45	0	0
10	32	12	0	0	72,73	27,27	0	0
Average Score: 3,45								
Minimum Score: 3								
Maximum Score: 4								

Based on the results of the analysis of the student response questionnaire shown in Table 10, it can be seen that 100% of students, or 44 students, gave a positive response to the implementation of the TGT learning model. None of the students selected "disagree" or "strongly disagree." Therefore, the minimum score obtained is 3, the maximum score obtained is 4, and the average score is 3.45. Thus, it can be stated that the implementation of the TGT learning model on global warming material received positive responses from students.

This aligns with the research conducted by Sudimahayasa [33], Haryanto [34], and Ghaemi *et al.* [35], which revealed that students gave a positive response to the implementation of the TGT model in learning because it enhances their discussion skills. These skills include listening to others' opinions, understanding problems, expressing ideas or opinions, staying on task, and actively concluding discussion results.

The findings of this study suggest that the implementation of the TGT learning model significantly enhances students' HOTS and learning motivation. However, this study undoubtedly possesses several shortcomings. The small sample size limits the findings' generalizability to a larger population and diverse learning contexts. Furthermore, the quantitative method employed in this study may insufficiently capture the complexities of students' learning experiences, thus requiring further research using qualitative methods such as conducting interviews and classroom observations. Future research should integrate relevant learning models and media to improve student engagement, foster HOTS, and equip students to address global challenges, including climate change and global warming. While aligned with prior research, further investigation is necessary on the factors influencing student HOTS and learning motivation, including student demographics, learning environment, and technology accessibility. Furthermore, it is essential to evaluate the consistency of the TGT learning model's efficacy across various physics topics and its impact on other cognitive and affective dimensions of students to gain a more comprehensive understanding.

The TGT model stands out in its ability to promote students' HOTS and learning motivation through the integration of teamwork, gamification, and competition. In contrast to other cooperative models like Student Teams-Achievement Divisions (STAD), which mainly emphasize group rewards, the TGT model incorporates interactive games that stimulate cognitive processes beyond mere rote memorization, thereby fostering deep learning and helping maintain students' motivation. Studies indicate that the game-based aspect of TGT fosters an enjoyable and challenging atmosphere, enhancing cognitive engagement among learners. Furthermore, the tournament phase of TGT brings a level of competition that is absent in models such as Jigsaw. While Jigsaw emphasizes the importance of collaboration by breaking tasks into interdependent parts, TGT combines cooperation with competition, achieving a balance that enhances motivation [36], [37]. Other studies also suggest that this gamification approach not only enhances cognitive engagement but also creates an inclusive environment. In such an environment, every student feels valued, leading to a notable rise in motivation, especially for those who might otherwise be disengaged [38], [39]. Future research should investigate the long-term impacts of the TGT model on student academic outcomes across diverse physics topics, as well as how various demographic factors predict students' HOT and learning motivation.

4. CONCLUSION

This study concluded that, based on the stacking test analysis, students' HOTS and learning motivation improved after the implementation of the TGT-type cooperative learning model. The findings from the data analysis indicate a significant impact of the TGT learning model on enhancing students' HOTS, categorized as a large effect size, and students' learning motivation, which falls into the medium effect size category. Additionally, the implementation of the TGT learning model on global warming material over three meetings was very well executed and received positive responses from students. These findings suggest that educators should consider incorporating TGT into their teaching practices to move away from rote memorization and toward HOTS, leading to more engaging and effective learning environments. This study implies that educators may consider adopting the TGT learning model to foster a more dynamic educational atmosphere, which ultimately contributes to better student academic outcomes and increased enthusiasm for learning.

AUTHOR CONTRIBUTION STATEMENT

LA contributed to conceptualization, methodology, validation, supervision, and manuscript review. AWG contributed to formal analysis, data collecting using software, data curation, and writing original draft preparation. TF contributed to writing, reviewing, and editing. SR contributed to data collecting and data curation. AN contributed to the conceptualization and manuscript review.

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