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The Effect of Snowball Throwing Cooperative Learning Assisted by PhET Simulation on Students' Physics Learning Outcomes and Responses on Heat Material

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Abstract

In an effort to increase student involvement and maintain the diversity of models in the teaching and learning process, a variety of learning models are needed. The combination of a snowball throwing model assisted by PhET simulation can provide a more interactive and in-depth learning experience for students. The purpose of this research is twofold: first, to examine the effect of the snowball-throwing cooperative model assisted by PhET on learning outcomes and learning responses of physics students in high school. This research used pseudo-experimental research, known as a pseudo-experiment with a quantitative approach. The population in this study was SMAN Rambipuji. The sample used was grade 11 students. Sampling in the study used cluster random sampling and homogeneity testing, constituting the research sample as an experimental class and a control class. This research shows a significant increase, namely in the value of Asymp. Sig. (2-tailed) $0.000 < 0.05$ on the physics learning outcomes of high school students who use the cooperative snowball throwing model assisted by PhET simulation. Apart from that, there was a significant difference between the cognitive, affective and conative dimension scores of the experimental group students compared to the control group. This shows that students have a better understanding of the material, high learning motivation, and the ability to actively ask and respond to questions when using the snowball-throwing cooperative model assisted by PhET simulations on learning outcomes and responses to physics learning.

Keywords: learning outcomes; learning response; snowball throwing

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INTRODUCTION

Physics is one of the most important subjects that help students understand natural events. Physics is important in helping students grasp scientific concepts and natural occurrences by applying mechanics, optics, electricity, and thermodynamics to real-world scenarios, thus facilitating learning (Çetin, 2016). Even so, understanding physics topics is

sometimes challenging for students (Simanullang et al., 2021). According to Ornek (2008), most physics concepts are difficult for students to imagine. One of the difficult concepts in physics to teach and learn is heat.

While previous studies, like those by Sari (2023), have highlighted the general challenges students face in understanding physics, they often do not specifically



address the concept of heat. Moreover, more research is needed on effective teaching strategies that directly tackle these specific difficulties. This study aims to fill that gap by exploring methods to teach the concept of heat better, thereby addressing the limitations of previous research.

Understanding this concept is crucial as it is interconnected with other fields, such as chemistry, biology, and medicine, influencing physical changes, reaction rates, and temperature measurements (Leong et al., 2016). A lack of understanding in physics often results in students achieving lower scores than other subjects. One of the contributing factors to this low understanding is the need for more implementation of effective learning models (Charli et al., 2019).

In addition, students assume that physics subjects are difficult, and they find them difficult because their environment influences them (Ekici et al., 2016). Student learning outcomes that could be better or more responsive in the learning process arise because of a lack of interest in participating in physics learning.

One of the causes is the teaching methods commonly used in the classroom, such as direct learning models that dominate, such as lectures and assignments (Dudelianny et al., 2021). In addition, in learning at school, sometimes a teacher needs to be right in choosing the method to use, less precise in identifying student learning problems, or less precise in evaluating student work results (Sefira et al., 2024). In an effort to increase student involvement and maintain model diversity in the teaching and learning process, a variety of learning models is needed. Through the snowball-throwing model, students can concentrate on problem-solving and understanding concepts in small groups (Arif, 2017).

The snowball-throwing cooperative learning model is one of the learning

models that develop from a conceptual approach. In this model, group representatives throw questions or thoughts onto a piece of paper written on it and roll into a ball like a snowball. (Husen et al., 2020). This learning model is an adaptation of a method that emphasizes the ability to compile questions and is used with exciting games such as "throwing snowballs" that combine questions (Smeltzer et al., 2020). Because students in this learning style are engaged in thinking, writing, or discussing and in physical interactions that encourage active involvement in the teaching-learning process, learning groups become more dynamic (Amin et al., 2022).

In addition to learning models that can help learning, interesting learning media greatly impact student learning outcomes (Deta et al., 2021). Fun and interactive learning media are important in student learning (Kustyarini et al., 2020). Learning media are needed that can explain physics concepts to support physics learning outcomes (Purfiyansyah et al., 2023). One example is PhET simulation media, which helps students understand physics through interactive simulations in the form of software. PhET (Simulations or Physics Education Technology) allows students to learn the principles of physics interactively (Ramadani & Nana, 2020). PhET simulation is a science and mathematics learning simulation that is free to use (Mallari & Lumanog, 2020). This simulation allows students to learn in a fun and motivated environment by exploring and innovating (Özcan et al., 2020). These simulations provide a virtual environment for observation and experimentation with physics concepts. This visualization helps students understand difficult physical phenomena (Pursilasari et al., 2023).

Combining snowball throwing models and PhET simulations can give students a more complex and interesting

educational experience. The use of snowball-throwing models encourages students to work together in groups to overcome various problems and understand physics concepts together (Haryana et al., 2023). PhET simulations aid in exploring physics concepts, where students can conduct virtual experiments and observe the results directly (Abadi et al., 2023). Multimedia-assisted cooperative learning, one of which is PhET, is able to improve the ability to master concepts, which include knowledge, understanding, concept application, analysis, evaluation and creation (Nuraini & Supriadi, 2018). This combination allows students to apply physics concepts in real contexts and deepen their understanding.

Student learning response is an action that arises when the teacher provides stimuli or responses to learning that students receive with satisfaction (Adam et al., 2020). Most students will focus on the learning process because of their interest in teaching materials, and students will not quickly feel bored with learning (Midroro et al., 2021). According to Mangei (2021), there are three responses: cognitive, affective, and conative. Cognitive response refers to a person's knowledge, skills, or information about something, appearing when there is a change in the audience's understanding or perception (Quoquab & Mohammad, 2020). When an audience's liking for something changes, affective responses related to one's feelings, attitudes, and considerations toward something happen. Affective response is a response to feelings towards a particular object or idea, a common reaction to something liked or disliked, namely in the form of emotions (Snow & Farr, 2021). Conative responses are concerned with concrete actions, including behaviours and habits. Student responses can be interpreted as reactions that arise when learning something with one's feelings (Faryanti et al., 2016).

Student response in learning is very important, because from the response, teachers can direct students' thinking to be better and correct (Efendi et al., 2021). According to Asmariati (2020), the snowball-throwing model has several advantages that can improve student response and learning outcomes. First, the model encourages collaboration and interaction between students. Furthermore, the snowball-throwing model teaches critical thinking skills and a more thorough understanding of the material taught. Conducting small group discussions, students can exchange opinions, provide arguments, and find solutions together (Siahaan et al., 2019).

Several previous studies have explored snowball-throwing type cooperative learning models in physics learning; for example, research by Ripani & Makiyah (2021) shows that applying snowball-throwing models can improve students' understanding of concepts and communication skills. In addition, research by Nurjanah (2024) shows that this model encourages active participation and collaboration among students, leading to a deeper understanding and retention of physics concepts. In addition, Susilawati et al. (2022) also stated that using PhET simulation media in physics learning can increase student motivation and problem-solving skills. Then, PhET simulation increases students' proficiency in physics and makes learning more enjoyable (Jayanagara & Lukita, 2023).

However, such studies generally separate the use of cooperative learning models and PhET simulations or focus only on one approach. Research by Nuraini & Supriadi (2018), for example, shows that the use of multimedia such as PhET can improve mastery of physics concepts but does not combine it with cooperative learning models.

The novelty of this study lies in the simultaneous use of snowball-throwing models and PhET simulations. This

approach combines the collaborative aspects of snowball-throwing models with the interactivity and visualization of PhET simulations. This study aimed to examine the effect of the PhET-assisted snowball-throwing cooperative model on the learning outcomes and learning responses of physics students in high school.

METHOD

This research utilized a quasi-experimental design with a quantitative approach (Sugiyono, 2020). Quasi-experimental research is a research method with a control group that cannot function fully to control outside variables that affect the implementation of experiments (Aditiany, 2021). The target population for this study was drawn from a high school in Jember Regency, with the sample consisting of grade XI students from the even semester of the 2023/2024 academic year. Sampling was conducted using cluster random sampling and a homogeneity test to designate the experimental and control groups. This research design uses a nonequivalent control group design, the approach in this design uses two randomly selected subject classes (Singh, 2021). The experimental class was treated with a snowball-throwing cooperative model integrated with PhET simulations, while the control class used the conventional teaching methods typically employed by the teacher. The classes were considered equal in various relevant aspects, with the only difference being the applied treatment.

This study integrated the snowball throwing model with PhET simulations

to improve student learning. The implementation began with the teacher introducing the learning objectives and motivating students by relating the material to real-world applications. Detailed information about the lesson was then provided. Students were divided into small groups of five to six people and instructed on using the snowball-throwing method. Each group was tasked with discussing the material and creating questions related to the content using the PhET simulations. The groups then exchanged their question papers and were required to answer questions from other groups based on the results of the discussions and simulations. The answers were recorded on worksheets and reviewed during class discussions. Finally, the teacher evaluated the groups' answers and positively reinforced their efforts.

One of the data collection techniques used in this study was through tests and questionnaires. Tests were conducted to measure students' cognitive abilities, with pre-tests and post-tests administered to assess their cognitive development. The questionnaire measured students' learning responses to the cooperative snowball throwing model assisted by PhET simulations in physics learning. Questionnaires were given to students after they completed the post-test as part of the evaluation of physics learning. The questionnaire was designed based on three cognitive, affective, and conative dimensions and included ten statements. The questionnaire was in the form of a Likert scale. Statement indicators were presented in Table 1.

Table 1 Student responses from the questionnaire

Variable	Dimension	Indicator	Item Number
Response	Cognitive (Opinion)	Understanding of the material	1, 2
		Understanding using learning media	3
		Understanding of the display of learning media	4, 5

Variable	Dimension	Indicator	Item Number
	Affective (Feelings)	Motivation	6
		Highlights	7
		Curiosity	8
	Conative (Action)	Ask	9
		Respond to inquiries	10
Total			10 Questions

Data analysis techniques were used to test the hypotheses regarding learning outcomes and student learning responses. If the values were normally distributed, hypothesis testing was performed using the Independent Sample T-Test, conducted with the help of IBM SPSS Version 25 software. If the normality test indicated that the data were not normally distributed, the hypothesis testing was carried out using the Mann-Whitney U-Test. Additionally, the collected questionnaire responses were analyzed. After the learning process, questionnaires were distributed in both the control and experimental classes. Data on student

learning responses were obtained from the questionnaire sheets, which used Likert scales.

RESULT AND DISCUSSION

The researchers aimed to test the effect of the snowball-throwing cooperative model assisted by PhET simulations on student physics learning outcomes. To this end, statistical tests were conducted using SPSS. The normality test aimed to determine whether the data followed a normal distribution. The results of the normality test for learning outcomes are summarized in Table 2.

Table 2 Learning outcome normality test results

Group		Kolmogorov-Smirnov ^a			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Outcomes	Control Pre-test	.246	33	.000	.849	33	.000
Learning	Control Post-test	.330	32	.000	.738	32	.000
	Experiment Pre-test	.192	34	.003	.918	34	.014
	Experiment Post-test	.361	34	.000	.779	34	.000

a. Lilliefors Significance Correction

The Kolmogorov-Smirnov test results indicated that both pre-test and post-test values for the control and experimental groups were below the significance level of < 0.05 , suggesting that the data were not normally distributed. Consequently,

the Independent Sample T-Test was replaced with the Mann-Whitney U-Test to compare the experimental and control groups. The Mann-Whitney U-Test results are presented in Table 3.

Table 3 Mann-Whitney test output results

Learning Outcome	
Mann-Whitney U	89.000
Wilcoxon W	617.000
Z	-6.137
Asymp. Sig. (2-tailed)	.000

a. Grouping Variable: Group

The Mann-Whitney U-Test results showed a significance value of $0.000 < 0.05$, indicating a significant difference between the experimental and control groups. This suggests that the snowball throwing model assisted by PhET simulations significantly impacted student physics learning outcomes, with the experimental group performing better than the control group. Therefore, the

average value of understanding heat material of students in the experimental group is significantly superior to that of the control group.

The response questionnaire also carried out normality tests and student learning outcomes. Table 4 shows the data that test the normal distribution in the response questionnaire.

Table 4 Results of the normality test of the physics learning response questionnaire

	Group	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Results of the Response Questionnaire	Control group	.131	33	.165	.973	33	.553
	Experimental group	.211	34	.001	.947	34	.100

a. Lilliefors Significance Correction

The normality test results showed that the control group data were normally distributed (Sig. $0.165 > 0.005$), while the experimental group data were not (Sig. $0.001 < 0.005$). Therefore, the Mann-Whitney U-Test was used to

analyze the questionnaire responses further. The results are divided into three dimensions: cognitive, affective, and conative, with details provided in Tables 5, 6, and 7.

Table 5 Mann Whitney test output results in cognitive dimensions

Cognitive Dimension Score	
Mann-Whitney U	103.000
Wilcoxon W	664.000
Z	-5.803
Asymp. Sig. (2-tailed)	.000

a. Grouping Variable: Control and experimental groups

The Mann-Whitney U-Test for the cognitive dimension showed a Sig. $0.000 < 0.005$, indicating a significant difference between the control and

experimental groups. The experimental group scored higher in cognitive dimensions, reflecting better understanding and use of learning tools.

Table 6 Mann Whitney affective dimension test output results

Affective Dimension Score	
Mann-Whitney U	297.000
Wilcoxon W	858.000
Z	-3.446
Asymp. Sig. (2-tailed)	.001

Grouping Variable: Control and experimental groups

For the affective dimension, the Mann-Whitney U-Test yielded a Sig. $0.001 < 0.005$. This result confirmed a significant

difference, with the experimental group demonstrating higher motivation, attractiveness, and curiosity scores.

Table 7 Conative dimension Mann Whitney test output results

Conative Dimension Score	
Mann-Whitney U	372.500
Wilcoxon W	933.500
Z	-2.582
Asymp. Sig. (2-tailed)	.010

a. Grouping Variable: Control and experimental groups

Lastly, the Mann-Whitney U-Test for the conative dimension resulted in a Sig. $0.010 < 0,005$. This indicates a significant difference in scores for asking and responding to questions, with the experimental group outperforming the control group.

The purpose of the first study was to examine the effect of the PhET-assisted snowball-throwing type cooperative model on the physics learning outcomes of high school students. The learning outcomes assessed are cognitive domains with ten multiple-choice questions. Learning in the experimental group was adjusted to the syntax of the PhET simulation-assisted snowball throwing model; namely, before teaching and learning activities began, researchers provided pre-test sheets to determine students' mastery of initial concepts. Then, in each meeting, the teacher conveys student learning goals and responses, presents learning material, namely heat material, and organizes students into study groups consisting of 6-7 students with heterogeneous group divisions. In addition, student worksheets are provided to each study group with the help of a PhET simulation, and then students are directed to discuss. After that, each study group makes questions in the form of balls and throws them to other study groups to answer, then make presentations. Students evaluate the answers to questions received from other groups. At the end of the learning activity, the researchers provide post-test sheets to measure learning outcomes and the extent to which students have mastered and understood the physics material delivered during learning. Meanwhile, learning in the control group

was adjusted to the PBL model. Students are given problems regarding heat material at each meeting with three face-to-face meetings. At the meeting, a pre-test was held to determine the mastery of students' initial concepts and a post-test to determine the mastery of students' final concepts after learning with different treatments, as well as providing questionnaires to students to find out students' physics learning responses with different treatments. After that, a presentation is made, and the teacher explains how to strengthen the material.

The Mann-Whitney test results in Table 2 demonstrated that the PhET simulation-assisted snowball throwing cooperative model significantly impacted student learning outcomes, as indicated by descriptive statistical analysis, which revealed that the average learning outcomes of the experimental group were higher when compared to the control group. Learning outcomes in experimental groups can be caused by applying a snowball-throwing cooperative model that encourages active student participation. This learning success increases because students are able to make consistent connections between concepts and contexts when learning using the snowball-throwing model (Felzmann, 2014). This model invites students to interact directly, express ideas, and compete in groups, increasing student involvement in learning (Santika, 2019).

Students engage in interactive teaching and learning through the snowball-throwing model while collaborating. In an atmosphere that allows students to exchange ideas and understanding, complex concepts

become clearer because of active discussions and mutually supportive learning among group members (Lestari et al., 2023). Then heterogeneous group division is also a factor that helps the interactive learning process; each group member will support each other and be motivated to achieve group success. This ensures that each member gets a fair chance to contribute to achieving the group's goals (Jaelani, 2015). This means that heterogeneous division aims to solve a common goal.

The discussion method gave rise to the snowball-throwing learning model, which is included in the cooperative learning model. Learning activities can be made more interesting and fun by designing learning activities according to this model. The advantage of the snowball-throwing model is that it allows students to develop study and practical skills, work together, and understand and respect themselves (Employee, 2022). Another addition to the snowball-throwing model is that it can foster students' confident attitudes towards delivering responses during learning and encourage active involvement and creativity in the learning process (Handayani, 2017). This allows students to have the opportunity to truly understand and absorb the learning material into the student's understanding and knowledge personally.

The use of the snowball-throwing learning model also has challenges. One of them is the difficulty in adapting and managing students when applying the snowball-throwing model, especially for students who are not familiar with this model. Students find it difficult to adhere to the learning steps using the snowball throwing model, resulting in less focused discussion time because students focus more on solving problems during learning. Another challenge is that some students tend to rely on their group mates, which can result in a lack of motivation, as well as when the group leader asks

members to write questions based on the material presented. In contrast, some students write questions irrelevant to the material discussed. Rahma (2023) confirmed that when implementing the snowball-throwing learning model, several challenges were faced, including a lack of participation from many less active students, a lack of initiative in asking questions and a tending to lack of voicing students' ideas or thoughts caused by students' dependence on group mates. Then, Sauduran (2021) also stated that another challenge is that during learning activities, group leaders who are less able to provide good explanations, of course, become an obstacle for other members to be able to understand the subject matter, so it takes a long time for students to discuss the subject matter.

For the second objective, which focused on examining the effect of the PhET-assisted snowball throwing model on students' physics learning responses, the analysis addressed cognitive, affective, and conative dimensions. Table 4 presents the normality test results for these dimensions, revealing significant differences between the experimental and control groups. The Mann-Whitney Test results, as shown in Tables 5, 6, and 7, indicated significant differences in cognitive, affective, and conative dimensions, with the experimental group achieving higher scores in all aspects. This suggests that the PhET simulation-assisted snowball throwing model significantly influences students' responses to learning physics. The questionnaires, which included 10 Likert scale statements, were administered to both control and experimental groups after the post-test activities. The findings confirm that the PhET simulation-assisted snowball throwing model notably improves the cognitive, affective, and conative dimensions of high school students' physics learning responses. This underscores the substantial impact of the

PhET simulation-assisted snowball throwing model on enhancing students' overall engagement and understanding of physics.

Assessment of student learning responses based on three main dimensions: cognitive, affective, and conative. In the cognitive dimension, there are three aspects assessed. The first is understanding the material. The use of snowball throwing models assisted by PhET simulation in physics learning can be easily understood by students and increase student knowledge. The second is understanding the use of learning media; using PhET simulation makes it easier for students to apply it. The last is an understanding of the display of learning media. The PhET simulation uses appropriate colour displays and attractive and easy-to-understand typefaces and writing colours, thus helping students read them better.

In the affective dimension, there are three more aspects. Motivation is first because using PhET simulation media that displays laboratory visuals such as images and animations can increase student learning motivation. This is reinforced by students' enthusiasm for learning and new innovations in using learning media. The second is interestingness, namely the PhET simulation learning media in this study has a colourful design and attractive animation so that students are interested and do not feel bored when using it in the teaching and learning process. The last is curiosity. Since students' interest in PhET simulation learning media is used to study heat material, many students become more focused on learning and not saturated during the learning process.

Finally, the conative dimension is assessed based on two indicators. First, the ability to ask questions is increased due to the use of snowball throwing models with PhET simulations, which makes students more active in learning heat material freely and stimulates

students who have difficulty asking the teacher questions. The second indicator is the response to questions, where the more students have information, the more questions are asked by students. The evaluation results proved that the experimental group scored higher than the control group in most assessments. This proves that the snowball-throwing cooperative model, with the help of PhET simulation, effectively strengthens student learning responses in various aspects of learning.

The use of PhET simulation media is also proven to significantly contribute to increasing student achievement in terms of material understanding, learning motivation, learning interest, and conative abilities such as asking and responding to questions. The factor that causes the experimental group to have a very good response achievement result value compared to the control group is that the combination of snowball throwing models with PhET simulations is able to create a stimulative and immersive learning environment. PhET contains theoretical and experimental simulations that actively engage with students. Users can manipulate experiment-related activities. Therefore, in addition to training concepts, PhET can also be used to help students' activeness and interest in learning physics (Faiqoh et al., 2019). The snowball-throwing model allows students to collaborate, share knowledge, and learn from their group mates (Lestari et al., 2023). Meanwhile, PhET simulation reinforces understanding of concepts through visual and practical experiences.

This has been conveyed by Prihatiningtyas (2013); using PhET simulation significantly impacts students' psychomotor skills, which tend to be more motivated when students learn by applying the knowledge gained by utilizing PhET simulation. To help students understand concepts better, the

PhET simulations can be used to simulate experiments and inspire students to do their experiments at home (Arifin et al., 2022). The PhET simulation as a learning aid has proven to improve student learning responses significantly. The PhET simulation provides an interactive learning experience, allows students to conduct virtual experiments, observe cause-and-effect relationships in the context of physics, and develop a deep understanding of complex physics concepts (Darwis, 2021). In addition, PhET simulation can meet practicum needs by providing visual details, such as material about heat that shows a simulation of heat energy that comes out and is received.

PhET simulation can adapt to student needs and overcome challenges that may arise during the learning process, considering that PhET simulation has advantages and disadvantages that need to be considered (Mardhatilla, 2021). The obstacle in this study is that when students use the PhET simulation, students lose focus on the learning objectives because they are distracted by the interesting features contained in the simulation. This was also conveyed by Serevina (2021). The students cannot directly experience using laboratory tools and materials, and some PhET simulations are too complex for students who do not understand the basic physics concepts correctly. The success of the learning process using PhET Simulation depends heavily on the independence of participants, which is one of the weaknesses of PhET Simulation. There is no monitoring from interested parties to monitor participants' teaching and learning process. The second drawback of using PhET simulation depends largely on the participants' equipment or the university's computer devices. The third drawback is that participants who are not proficient or less proficient in using computers will feel very uncomfortable using PhET simulations

(Ruwiyah et al., 2021). Overall, using PhET simulation-assisted snowball throwing-type cooperative models effectively improved high school students' learning responsiveness in physics. It provides a holistic, immersive, and interactive learning experience, positively influencing students' understanding of concepts and learning motivation. simulations (Ruwiyah et al., 2021).

CONCLUSION

Based on the results of the research, it was concluded that the use of a snowball-throwing cooperative model assisted by PhET simulation has a significant effect on the physics learning outcomes of students in high school. This is evident from the analysis results, which showed an increase in the average value of the experimental group's learning outcomes compared to the control group. The snowball-throwing model encourages students to actively interact in learning actively, thus enabling the exchange of ideas and understanding between students. PhET simulation in the learning model also contributes significantly to student learning responses, especially in cognitive, affective, and conative dimensions. Students demonstrate a better understanding of the material, high learning motivation, and the ability to ask and respond to questions actively. The advantages of PhET simulation include attractive visualization, ease of use, and practical experience that deepens understanding of physics concepts. Although effective, several obstacles need to be faced in applying the PhET simulation-assisted snowball throwing model, such as the difficulty of adjusting students to the model and the occurrence of student distraction by interesting features in the simulation. Overall, the PhET simulation-assisted snowball throwing type cooperative model provides a holistic, interactive, and

immersive learning experience that positively influences students' understanding of concepts and learning motivation in high school in physics subjects.

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