

Implementing Game-Based Learning to Improve Students' Collaboration and Learning Outcomes on Work, Energy, and Simple Machines

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Abstract. This study aims to describe the implementation of Game-Based Learning (GBL) assisted by Kahoot and to analyze the improvement of students' collaboration skills and learning outcomes on the topic of work, energy, and simple machines in class VIII A of SMP Adhyaksa 1 Jambi. This research employed Classroom Action Research conducted in two cycles consisting of planning, action, observation, and reflection stages. The research subjects were 17 students. Data were collected through collaboration observation sheets and learning achievement tests, then analyzed descriptively and inferentially. The results showed that students' collaboration skills improved from 50.81% in Cycle I to 63.83% in Cycle II, categorized as good. Learning outcomes also showed significant differences based on the Friedman test ($\chi^2(2) = 13.447$; $p < 0.05$). The paired sample t-test, which was conducted to evaluate students' learning outcomes, indicated a significant difference between the initial and final collaboration scores, with a Cohen's d effect size of 1.42 (large category). These findings indicate that the implementation of GBL assisted by Kahoot is effective in enhancing students' collaboration skills and learning outcomes. Therefore, this approach can serve as an innovative instructional strategy in physics learning at the junior high school level.

Keywords: Game-Based Learning, Kahoot, collaboration skills, learning outcomes

1. Introduction

Physics learning plays an important role in developing students' critical, logical, analytical, and systematic thinking skills. Physics is not only focused on mastering concepts and mathematical formulas but also on the ability to understand natural phenomena scientifically and apply concepts in everyday life. Ideally, the physics learning process should encourage students to build knowledge through observation, discussion, and active problem-solving. However, in practice, physics learning is still often dominated by expository and lecture-based approaches, so students receive more information rather than being directly involved in the process of knowledge construction [1]. This condition affects the low conceptual understanding and the underdevelopment of higher-order thinking skills of students [2].

The topics of work, energy, and simple machines are fundamental parts of the junior high school science curriculum because they are directly related to various human activities, such as moving objects, using mechanical aids, and utilizing energy in daily life. The characteristics of these topics require contextual and interactive learning so that students can understand the relationship between physics concepts and real-world phenomena around them. If learning focuses only on solving problems procedurally without discussion and exploration of the meaning of concepts, the understanding gained tends to be shallow and easily forgotten [2]. Therefore, a learning approach that can integrate cognitive and social aspects in a balanced manner is needed.

The Merdeka Curriculum emphasizes student-centered learning and the strengthening of the Pancasila Student Profile, including the abilities to collaborate, think critically, and communicate

effectively [3]. In the context of 21st-century learning, mastering the 4C skills (critical thinking, creativity, collaboration, and communication) is a primary requirement that must be developed through classroom activities [4]. Collaboration skills, in particular, play an important role in building understanding through social interactions, group discussions, and the exchange of ideas among students [5]. The collaborative process allows students to complement each other's knowledge, clarify concepts that are not yet understood, and develop mutual respect in teamwork.

The initial observation conducted at SMP Adhyaksa 1 Jambi showed that learning is still dominated by the use of modules, student worksheets, and PowerPoint presentations with limited interaction patterns. Group discussions are not running optimally, and active student participation in collaborative activities reaches only around 40%. This situation indicates that the learning process has not fully encouraged active involvement and the development of students' social skills. Meanwhile, learning media play a strategic role in helping teachers deliver material while bridging abstract concepts with students' real-life experiences [6]. The use of less varied media can reduce motivation and interest in learning, which in turn affects less optimal learning outcomes.

One approach that can be used to increase student engagement and interaction is Game-Based Learning (GBL). This approach integrates game elements into the learning process to create a more engaging, challenging, and enjoyable learning environment [7]. Game elements such as scores, challenges, and instant feedback can enhance students' intrinsic motivation and encourage active participation in learning activities. Research shows that the implementation of GBL in physics learning can significantly improve learning effectiveness, conceptual understanding, and information retention among students [8].

In its implementation, the use of digital platforms such as Kahoot can support the application of Game-Based Learning (GBL) more effectively. Kahoot is a technology-based interactive quiz medium that allows students to respond to questions in real time using digital devices. Its features, such as immediate feedback and ranking systems, can foster healthy competition while encouraging active participation and group discussion. Previous studies have shown that Kahoot can enhance students' motivation, engagement, and participation during the learning process [9], [17].

Several empirical studies at the national level have demonstrated the effectiveness of Game-Based Learning in improving students' learning outcomes and engagement. For example, Wulandari et al. reported improvements in collaboration skills and learning outcomes through cooperative game-based models [8]. In addition, Sakdah et al. found that Kahoot-based GBL significantly enhanced students' motivation and academic achievement [18]. Similarly, Damayanti et al. showed that the implementation of Game-Based Learning had a positive effect on students' learning outcomes [10]. Supporting these findings, other studies also revealed that GBL contributes to improving learning outcomes and student retention [32], [33].

At the international level, numerous studies have confirmed the effectiveness of GBL and Kahoot in educational settings. Wang and Tahir reported that Kahoot significantly improves students' engagement, motivation, and learning performance [29]. Similarly, Licorish et al. found that the use of Kahoot enhances classroom interaction and student participation [30]. Furthermore, Plump and LaRosa demonstrated that game-based response systems increase student attention and active involvement during learning [31].

However, most previous studies tend to focus primarily on cognitive achievement and learning motivation, while the integration of collaboration skills and learning outcomes simultaneously has received limited attention. Therefore, this study offers novelty by integrating both aspects through the implementation of Game-Based Learning assisted by Kahoot.

In light of this urgency, this study aims to analyze the effectiveness of implementing Game-Based Learning assisted by Kahoot in enhancing collaboration skills and learning outcomes of eighth-grade students (Class VIII A) on the topics of work, energy, and simple machines. The findings of this study are expected to contribute to the development of innovative and effective learning strategies that align with the demands of the Merdeka Curriculum and 21st-century learning, particularly in fostering both cognitive and social competencies.

2. Method

This study used a Classroom Action Research (CAR) design based on the Kemmis and McTaggart model, which includes four main stages, namely planning, action, observation, and reflection [11]. This model was chosen because it allows for systematic improvement of learning through continuous reflective cycles, making it suitable for enhancing the quality of both the learning process and student outcomes in a real classroom context [12]. The study was conducted in two cycles, with each cycle consisting of two learning sessions.

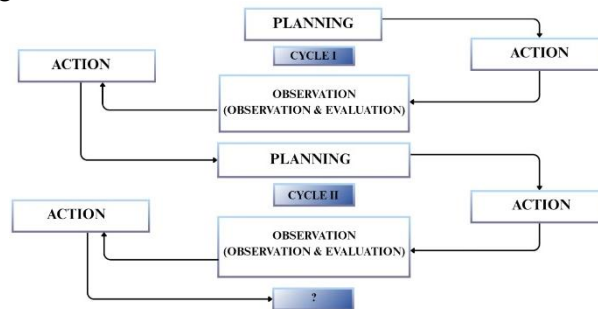


Figure 1. Classroom action research model by Kemmis & Taggart [33].

The implementation stage of the action was conducted by applying GBL-based learning using Kahoot as an interactive quiz medium. In practice, students were divided into heterogeneous groups to encourage social interaction and balanced cooperation among group members. The learning was designed to facilitate discussions, solving of contextual problems, and providing immediate feedback through interactive quizzes. The Game-Based Learning approach was used to boost student motivation, active involvement, and participation in learning [7]. The use of Kahoot allows for healthy competition and group discussions that support the development of collaboration skills [9].

The observation stage was carried out to monitor the implementation of learning, teacher and student activities, as well as the development of collaboration skills. Indicators of collaboration skills include individual responsibility, active participation in discussions, effective communication, commitment to group success, as well as harmony and teamwork [5]. Data were collected through observation, questionnaires, learning outcome tests, and documentation.

This study employed a Classroom Action Research (CAR) approach based on the model proposed by Kemmis and McTaggart, which emphasizes a cyclical process consisting of planning, action, observation, and reflection. Through this model, the learning process can be continuously improved based on reflection results in each cycle. In this study, the action research was conducted in two cycles, with each cycle consisting of two meetings aimed at evaluating and improving the implementation of Game-Based Learning assisted by Kahoot [12].

The type of CAR used in this study was collaborative classroom action research. Collaborative CAR involves cooperation between the researcher and the teacher in planning, implementing, observing, and reflecting on the learning process. In this study, the researcher acted as the practitioner who implemented the actions, while the subject teacher served as the observer. The use of this cyclical model is based on the reflective and continuous nature of CAR in improving the quality of the learning process [32].

The research subjects consisted of 17 students from Class VIII A. The sampling technique used was purposive sampling, which involves selecting subjects based on specific considerations. This class was chosen because the teacher provided the opportunity for the researcher to conduct the intervention in that class. In classroom action research, the use of a single class as the research subject is a common practice, as the research focuses on improving the learning process within a specific classroom context [21].

The research instruments included a Game-Based Learning-based teaching module, collaboration observation sheets, and learning outcome tests. Instrument validity was established through expert judgment on the developed teaching module, covering aspects such as content relevance, clarity of presentation, and alignment with learning objectives. Feedback from validators was used to revise and improve the learning materials before implementation.

Furthermore, data reliability was supported through the use of consistent instruments and systematic data analysis. To examine the differences between pre- and post-intervention results, a paired sample t-test was employed, as the data consisted of two related measurements obtained from the same subjects (pre-test and post-test). This test aimed to determine whether there was a significant difference after the implementation of the learning intervention. Therefore, this analysis provides a more accurate representation of the relationship between students' initial and final conditions.

3. Result and Discussion

3.1. Learning Device Validation Result

Before the implementation of the action, the learning device in the form of a teaching module based on Game-Based Learning (GBL) was first subjected to a validation process by two experts. This validation aimed to ensure the feasibility of the content, the suitability of the material, and the coherence of the learning steps with the research objectives. In addition, the validation process also focused on evaluating the clarity of instructions, the appropriateness of assessment components, and the alignment between learning activities and the expected learning outcomes. Feedback and suggestions provided by the validators were used as the basis for revising and improving the quality of the learning device before it was implemented in the classroom.

The learning device developed based on the Game-Based Learning (GBL) approach was revised according to suggestions provided by expert validators during the validation process. Several improvements were made to enhance the clarity, relevance, and alignment of the learning components with the intended learning objectives. One of the main revisions involved adding question grids and collaboration indicator grids in the Learning Assessment section. This improvement was intended to enhance the alignment between learning objectives and assessment instruments, ensuring that both students' conceptual understanding and collaboration skills are measured more systematically and accurately.

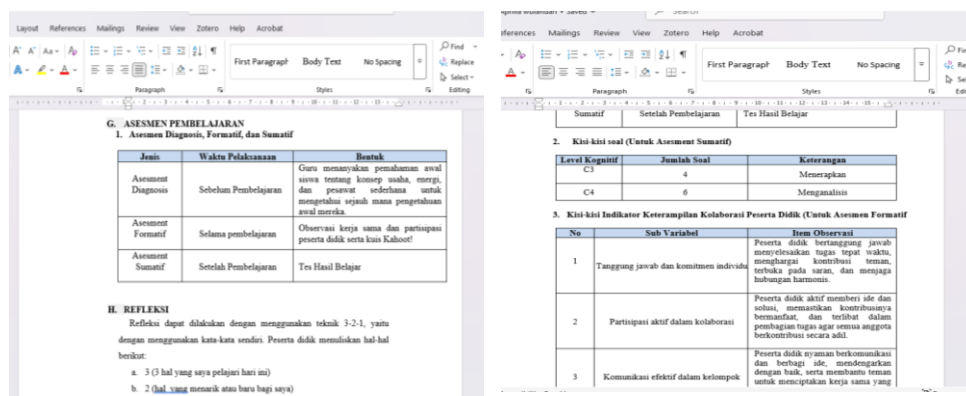


Figure 2. Addition of question grids and collaboration indicator grids.

The figure shows the results of the revision in the learning assessment section, specifically by adding question grids and collaboration indicator grids. This addition aims to clarify the alignment between learning objectives and the assessment instruments used, so that the measurement of students' conceptual understanding and collaboration skills becomes more structured and systematic. Furthermore, the presence of these grids helps ensure that all assessed aspects are in accordance with the predetermined indicators. Thus, the revisions made to the learning assessment section are expected to improve the quality of the assessment instruments and support the optimal achievement of learning objectives.

Based on the assessment by the first validator, the teaching module obtained a score of 47 out of a maximum score of 60, which is equivalent to 78.33% and falls into the category of feasible with revisions. Meanwhile, the validation results from the second validator showed a significant improvement after gradual revisions were implemented. The initial score of 33 (55%) increased to 46 (76.67%) in the second stage and further improved to 51 (85%) in the third stage. Therefore, the teaching

module can be declared suitable for use without further revisions after improvements were made according to the experts' suggestions.

Cycle I was conducted in two meetings using a Game-Based Learning (GBL) approach assisted by Kahoot on the topic of work and energy. The implementation of learning followed the stages of planning, action, observation, and reflection according to the Kemmis and McTaggart model. Observations were conducted by three observers using observation sheets for teacher and student activities, covering 20 aspects of the learning activities.

Cycle 1: Game-Based Learning
Approach by Kahoot



Figure 3. Cycle I learning scheme using game-based learning with Kahoot.

The observation results showed that student activity in cycle I was in the sufficient category. The implementation of learning in cycle I followed several stages, beginning with the introduction phase in which the teacher delivered the learning objectives and provided motivation to students. At this stage, students were introduced to the topic to be studied and were encouraged to actively participate in the learning process. Afterward, students were divided into groups to support collaborative learning activities and to facilitate interaction among group members during the lesson.

The learning process then continued with a game-based learning activity using Kahoot. Through this activity, students were involved in answering quiz questions related to the learning material. The use of Kahoot created a more interactive and engaging learning atmosphere, as students were motivated to compete and collaborate with their peers to achieve the best results. This activity also helped students to review and reinforce their understanding of the concepts that had been introduced earlier.

After participating in the Kahoot activity, students conducted group discussions to analyze the questions and concepts that had been learned during the activity. In this stage, students were encouraged to share their ideas, express opinions, and work together to solve problems related to the learning material. The learning process concluded with reflection and evaluation activities in which the teacher reviewed students' responses and identified difficulties encountered during the learning process. The results of this reflection were used as the basis for improving the learning implementation in the next cycle.

The observation results showed that student activity in cycle I was in the sufficient category. Although the learning process had been implemented according to the planned stages, several obstacles were still encountered during the implementation. Some students were not fully involved in group discussions and tended to rely on their more active peers when completing the assigned tasks. In addition, time management during the learning activities was not yet optimal, which affected the effectiveness of the discussion and reflection stages.

Based on the results of observations and reflections in cycle I, several improvements were considered necessary for the next cycle. These improvements included forming more heterogeneous groups, improving time management during learning activities, and providing more intensive motivation and guidance to students so that each member could actively participate in discussions and collaborative

learning activities. These efforts were expected to increase student engagement and improve the effectiveness of the learning process in the following cycle.

Cycle 2: Game-Based Learning
Approach Assisted by Kahoot

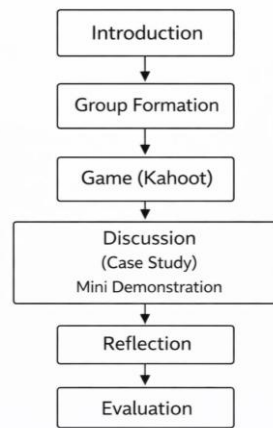


Figure 4. Learning treatment scheme in cycle II using game-based learning assisted by Kahoot.

Cycle II was carried out by improving the learning process based on the reflection results obtained from cycle I. The learning activities began with the introduction stage in which the teacher explained the learning objectives and motivated students to actively participate in the lesson. Students were then organized into groups in order to facilitate collaborative learning and to create opportunities for interaction among group members during the learning activities.

Similar to the previous cycle, students participated in a game-based learning activity using Kahoot to strengthen their understanding of the learning material. In cycle II, the implementation of the Kahoot activity was conducted more systematically so that students could focus better on answering the questions provided. The activity also encouraged students to actively participate and increased their motivation during the learning process.

Furthermore, the discussion stage in cycle II was improved by incorporating additional activities such as case study analysis and mini demonstrations to deepen students' conceptual understanding. Students were encouraged to actively express their opinions, exchange ideas, and collaborate with their peers in solving the problems provided. The learning process concluded with reflection and evaluation activities to review students' responses and discuss any difficulties experienced during the lesson. These activities helped the teacher assess students' understanding and measure improvements in their collaborative skills during the learning process.

To assess the effectiveness of the implemented learning strategy, students' learning outcomes were evaluated at each stage of the action, namely the pre-cycle, Cycle I, and Cycle II. The assessment was carried out using written tests to measure students' cognitive understanding of the learning material. The results of students' learning outcomes are presented in the following table.

Table 1. Students' cognitive learning outcomes.

Implementation of Actions	Mean (Average)	Median	Lowest	Highest
Pre-cycle	40.59	40	20	80
Cycle I	51.76	50	20	90
Cycle II	42.35	40	0	100

Based on Table 2, student learning outcomes showed variations across each stage of the action. In the pre-cycle, the average score was 40.59. After the implementation of Game-Based Learning in cycle I, the average score increased to 51.76, indicating an improvement of 11.17 points. This suggests that

the application of Game-Based Learning assisted by Kahoot had a positive impact on students' understanding of the material.

However, in cycle II, the average score decreased to 42.35, showing a decline of 9.41 points compared to cycle I. This indicates that the improvement was not consistently sustained in the second cycle. The decrease may be influenced by several factors, such as differences in student engagement, adaptation to the learning strategy, or variations in learning conditions during the implementation.

Nevertheless, when compared to the pre-cycle condition, the results in cycle II still show a slight improvement, indicating that the implementation of Game-Based Learning assisted by Kahoot contributed positively to students' learning outcomes overall.

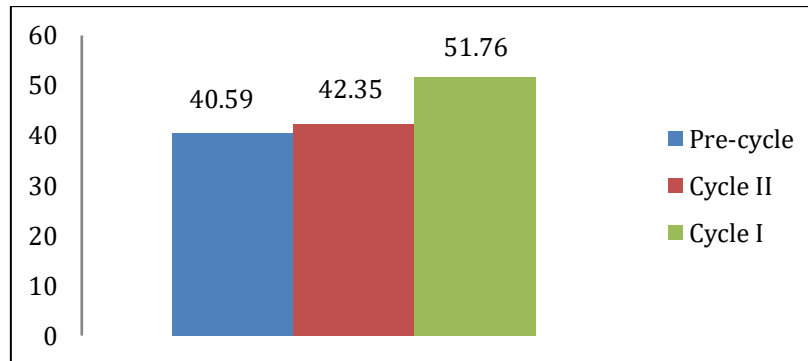


Figure 5. Graph of students' learning outcomes in each cycle.

Figure 5 shows the comparison of students' learning outcomes in each cycle. The average score increased from 40.59 in the pre-cycle to 51.76 in cycle I, indicating an improvement of 11.17 points. However, in cycle II, the average score decreased to 42.35, showing a decline of 9.41 points compared to cycle I. This indicates that although there was a significant improvement in cycle I, the results were not consistently maintained in cycle II. Nevertheless, when compared to the pre-cycle condition, the overall learning outcomes still show a positive improvement.

In addition to learning outcomes, students' collaboration skills were also observed during the implementation of the learning process. These observations were conducted to evaluate how students interacted, participated, and worked together in groups throughout the Game-Based Learning activities assisted by Kahoot. The results of students' collaboration skills are presented in the following table.

Table 2. Results of student collaboration observation sheet.

No.	Sub-variable	Observation Item	Cycle I		Cycle II	
			P1	P2	P1	P2
1	Individual responsibility and commitment	Learners are responsible, respect ideas, and maintain group cooperation.	41.86%	56.97%	61.62%	66.27%
2	Active participation in collaboration	Learners actively provide solutions and share tasks fairly.	44.18%	54.65%	60.46%	63.95%
3	Effective communication within the group	Learners are communicative, listen, and assist friends in the group.	47.67%	60.46%	67.44%	61.62%
4	Commitment to group success	Learners prioritize the group's interests and maintain discussion ethics.	46.51%	53.48%	65.11%	65.11%
5	Alignment and group cooperation	Learners support collective decisions and adapt for the group's goals.	43.02%	59.30%	63.94%	62.79%
Average			44.65%	56.97%	63.71%	63.95%
Criteria			C	C	B	B
Total			50.81%		63.83%	

Based on Table 2, students' collaboration skills improved from cycle I to cycle II in all observed sub-variables. In cycle I, the average collaboration skill score in the first meeting was 44.65% and increased to 56.97% in the second meeting, with a sufficient (C) category. These results indicate that at the initial stage of implementing Game-Based Learning, students began to show involvement in group work, although participation and communication were not yet optimal. From a social constructivist perspective, learning that involves discussions and group work allows students to build understanding through interactions with their peers [14].

A more significant improvement was seen in cycle II. The average collaboration skills in the first meeting reached 63.71% and increased to 63.95% in the second meeting with a good (B) category. All collaboration indicators, namely individual responsibility, active participation, effective communication, commitment to group success, as well as group harmony and cooperation, showed an increasing trend compared to cycle I. This indicates that the implementation of Game-Based Learning assisted by Kahoot can improve the quality of social interactions and students' active participation in learning [15].

Overall, the percentage of collaboration skills increased from 50.81% in cycle I to 63.83% in cycle II. This increase indicates that a game-based learning approach can strengthen teamwork and individual responsibility within a group [16]. Thus, this learning approach contributes to the gradual improvement of students' collaboration skills from cycle to cycle. The improvement in students' collaboration skills in each cycle is shown in Figure 6.

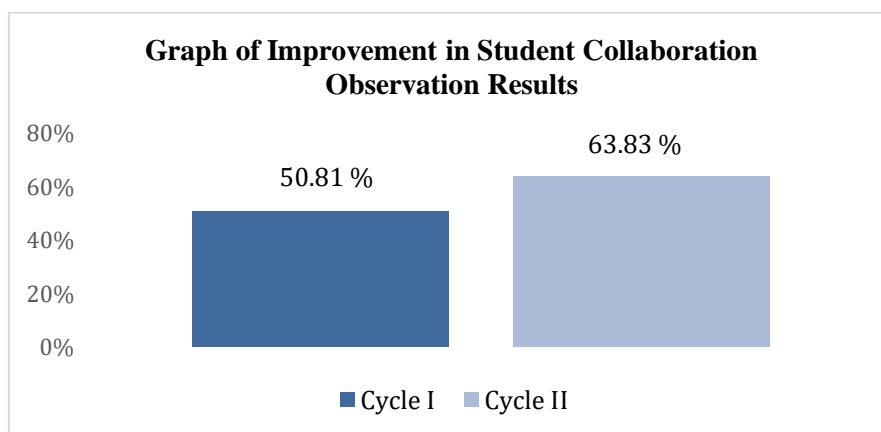


Figure 6. Graph of the improvement of students' collaboration skills in each cycle.

In addition to the improvement in collaboration skills, students' learning outcomes also showed an increase from cycle I to cycle II. Based on the learning outcomes graph, there is an increase in the average scores and the percentage of students' learning completeness in cycle II after improvements in the learning strategy were implemented. This indicates that the use of Kahoot media in a Game-Based Learning approach is able to support students' understanding of the concepts of work, energy, and simple machines more effectively.

The increase in learning outcomes indicates that active student involvement through interactive quizzes and the provision of immediate feedback plays a role in strengthening conceptual understanding. This finding aligns with previous research which states that game-based learning can enhance students' conceptual understanding and learning retention through question visualization and immediate responses to the answers given [5],[8].

The findings of this study indicate that the implementation of Game-Based Learning assisted by Kahoot is effective in improving students' learning outcomes and collaboration skills. This improvement is supported by the use of interactive quizzes and group discussions, which also enhance students' motivation and engagement during the learning process.

The Kolmogorov-Smirnov test results indicate that the data on the differences in student collaboration between cycles 1 and 2 are normally distributed [$D(17) = 0.130$, $p = 0.200$], with the assumption being fulfilled if $p > 0.05$. Based on the normality test results, the Kolmogorov-Smirnov

significance value is 0.200, and the Shapiro-Wilk significance value is 0.136. Both significance values are greater than the 0.05 significance level ($p > 0.05$), indicating that the data are normally distributed. After the data are confirmed to be normally distributed, descriptive statistics of the initial and final collaboration scores are presented as the basis for the difference test analysis. The data are shown in Table 5.

Table 3. Test of normality.

	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Difference	.130	17	.200*	.918	17	.136

*. This is a lower bound of the true significance

a. Lilliefors Significance Correction

Table 4. Paired samples statistics.

	Mean	N	Std. Deviation	Std. Error Mean
Pair 1 Collaboration_initial	67.2059	17	9.55585	2.31763
Collaboration_final	79.8529	17	6.40255	1.55285

After it was determined that the data were normally distributed, a paired t-test was conducted to determine whether there was a significant difference between the initial and final collaboration scores.

Table 5. Paired samples test.

		Paired Differences							
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
					Lower	Upper			
Pair 1	Collaboration_initial - Collaboration_final	-12.70455	8.90359	2.15944	-17.22486	-8.0696	-5.857	16	.000

There was a significant difference in students' initial collaboration test results before ($M = 67.20$, $SD = 9.55$) and after learning ($M = 79.85$, $SD = 6.40$), $t(16) = 5.857$, $p < 0.001$. A difference is considered statistically significant if $p < 0.05$.

The paired sample t-test is used because the data analyzed comes from two related measurements, namely students' collaboration scores before (pre) and after (post) the treatment on the same subjects. This test aims to determine whether there is a significant difference in the means between the two conditions, making it suitable for comparing changes in students' collaboration scores before and after learning. In addition to the significance test, this study also uses effect size to determine the magnitude of the treatment's impact. The significance value (p-value) only indicates whether a difference exists, but does not explain the actual size of the effect, so effect size is needed as a complement to the analysis.

In addition to testing the significance of the differences, this study also calculated the effect size to determine the practical impact of the treatment. The results of the effect size calculation are presented in Table 6.

Table 6. Paired samples effect size.

		Standardizer ^a	Point Estimate	95% Confidence Interval	
				Lower	Upper
Pair 1	Collaboration_initial - Collaboration_final	Cohen's d	8.90359	1.42	-2.091 -728
		Hedges' correction	9.11929	-1.1387	-2041 -711

The difference in student test results based on Cohen’s d value (1.42) is very large. This value indicates that the effect of the treatment has practical significance in an educational context [18]. Hedges’ correction is a correction method in the calculation of effect size used to reduce bias in small sample sizes. This correction produces a more accurate effect size than Cohen’s d when the sample size is relatively small. Hedges’ correction is used because the number of subjects is limited, so this correction helps provide a more reliable estimate of the magnitude of the effect on the difference in students' collaborative test results before and after learning.

Next, a normality test was conducted on the learning outcome data at each stage to determine the appropriate type of statistical test.

Table 7. Test of normality.

	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Residual for Pre-Cycle Learning Outcomes	.203	17	.060	.877	17	.029
Residual for Learning Outcomes Cycle 1	.216	17	.035	.914	17	.116
Residual for Learning Outcomes Cycle 2	.186	17	.119	.935	17	.268

The Kolmogorov-Smirnov test results indicate that the residual data of students' pre-cycle learning outcomes ($D(17) = 0.203, p = 0.060$) are normally distributed. The residual data of students' cycle II learning outcomes ($D(17) = 0.186, p = 0.119$) are normally distributed. However, the residual data of students' cycle I learning outcomes ($D(17) = 0.216, p = 0.035$) are not normally distributed.

Before conducting further analysis using repeated measures, a sphericity assumption test is first carried out to ensure the appropriateness of the analysis model. The results of this test are presented in Table 8.

Table 8. Mauchly’s test of sphericity^a.

Measure: Learning Outcomes							
Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Greenhouse-Geisser	Epsilon ^b Huynh-Feldt	Lower-bound
Time	.804	3.045	2	.218	.836	.926	.500

Mauchly’s Test indicates that the sphericity assumption is met, $X^2(2) = 3.045, p > 0.218$

Because not all data meet the assumption of normality, the Friedman test is used as a non-parametric alternative to examine the differences in learning outcomes between cycles.

Table 9. Test statistics.

N	17
Chi-Square	13.447
df	2
Asymp. Sig.	.001

a. Friedman Test

However, because the assumption of residual normality was not fully met, especially in the data from cycle II, hypothesis testing on student learning outcomes was conducted using the Friedman test as an alternative nonparametric test. The results of the Friedman test showed that there were significant differences in student learning outcomes during the pre-cycle, cycle 1, and cycle 2, $X^2(2) = 13.447, p < 0.001$.

The Friedman test is a nonparametric statistical test used to determine whether there are significant differences among three or more related measurements within the same group. This test is typically used as an alternative to a one-way repeated ANOVA when the data do not meet the assumption of normality. In this study, the Friedman test was used to compare students' learning outcomes in the pre-cycle, cycle I, and cycle II, originating from the same subjects, so that each measurement is related.

To determine the magnitude of the effect of learning activities on students' learning outcomes, an effect size calculation was carried out using partial eta squared, which is presented in Table 10.

Table 10. Tests of within-subjects effects.

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Time	Sphericity Assumed	1079.167	2	539.583	4.060	.028	.213
	Greenhouse-Geisser	1079.167	1.673	645.072	4.060	.036	.213
	Huynh-Feldt	1079.167	1.858	580.696	4.060	.031	.213
	Lower-bound	1079.167	1.000	1079.167	4.060	.062	.213
	Error (Time)	3987.500	30	132.917			
Error (Time)	Sphericity Assumed	3987.500	25.094	158.902			
	Greenhouse-Geisser	3987.500	27.876	143.044			
	Huynh-Feldt	3987.500	15.000	265.833			
	Lower-bound	3987.500					

The calculation of effect size using partial eta squared shows that the differences in student learning outcomes during the pre-cycle, cycle 1, and cycle 2 are indicated in the large category ($\eta^2 = 0.213$). This test involves three sets of data, namely pre-cycle learning outcomes, cycle 1 learning outcomes, and cycle 2 learning outcomes, so further analysis (post hoc) using LSD (Least Significant Difference) is required to determine the ranking of each data set.

To understand the comparison of students' learning achievement at each stage of learning in more detail, descriptive statistics are presented in Table 12.

Table 11. Descriptive starting point of student learning outcomes in each lesson.

Learning Outcomes	Mean (<i>M</i>)	Median (<i>Mdn</i>)	Std. Deviation	Notation
Pre-Cycle Learning Results	40.59	40.00	17.78	a
Learning Outcomes Cycle I	42.53	40.00	23.86	ab
Learning Outcomes Cycle II	51.76	50.00	19.12	b

The table shows an increase in student learning outcomes at each stage of learning. The highest average score (mean) was obtained in cycle 1 at 51.76, followed by cycle 2 at 42.53, and the pre-cycle at 40.59. The same pattern is also seen in the median scores, where the highest median was in cycle 1 at 50.00. This data indicates that the implementation of learning actions has a positive impact on improving student learning outcomes.

Based on the standard deviation (SD) values, the variation in student scores at each stage is still quite diverse, with the highest SD occurring in cycle 2 at 23.86, which indicates differences in individuals' abilities to receive and master the learning material [19]. Different notations at each stage indicate differences in learning outcomes between cycles, suggesting dynamics in the development of students' understanding during the action process [20].

Overall, the results indicate that the actions implemented in the learning process are able to improve students' learning achievements compared to before the actions were taken, in line with research findings stating that game-based learning effectively enhances learning outcomes in the context of science education [21]. The improvement in learning outcomes is closely related to the increased cognitive and social engagement of students during the learning process. Group discussion activities and interactive quizzes encourage students to be more active in constructing conceptual understanding through negotiation of meaning and collective reflection [22]. The integration of social and cognitive dimensions in learning has been proven to have a positive impact on the overall quality of education [23].

These findings indicate that the implementation of Game-Based Learning assisted by Kahoot is not only relevant in improving learning outcomes but also aligns with the demands of 21st-century education, which emphasizes a balance between students' academic competencies and social skills [24].

Thus, innovative learning strategies that combine digital technology and collaborative approaches become an effective alternative in enhancing the quality of physics education at the junior high school level [25]. This approach also supports the transformation of technology-based learning that positions students as active subjects in the process of knowledge construction [26]. Furthermore, the integration of interactive digital media in science learning is reported to be able to increase students' learning motivation and resilience in the long term [27].

3.2. *Challenges and Efforts for Improvement in the Implementation of Actions*

During the implementation of the classroom action research, there were several challenges faced in applying Kahoot-assisted Game-Based Learning. In the first cycle, the main obstacles included limited time management, technical readiness for using digital media, and the formation of groups that were not yet heterogeneous, so collaboration did not run optimally. Some students were also still passive and tended to rely on more active group members. Additionally, there were technical issues such as unstable internet connections and varying student abilities in operating digital devices. These conditions affected the smooth execution of interactive quizzes in the early stages of learning.

To address these challenges, several improvements were made in cycle II, namely the formation of heterogeneous groups based on academic ability, the provision of clear role assignments within each group, and technical guidance before using Kahoot began. The teacher also provided more intensive motivation and support to less active students. These improvements proved to enhance the effectiveness of learning in cycle II, as evidenced by increased student engagement, the quality of group discussions, as well as achievements in collaboration skills and overall learning outcomes.

4. Conclusion

Based on the results of the research and discussion, it can be concluded that the implementation of Game-Based Learning assisted by Kahoot effectively improves students' collaboration skills and learning outcomes on the topics of work, energy, and simple machines. Students' collaboration skills increased from 50.81% in cycle I to 63.83% in cycle II, indicating an improvement in students' participation, communication, and teamwork during the learning process. The statistical analysis results indicate a significant difference in student learning outcomes between the pre-cycle, cycle I, and cycle II. The effect size, categorized as large, shows that the impact of implementing game-based learning is not only statistically significant but also practically meaningful in an educational context. The integration of group discussion activities and interactive quizzes through Kahoot can simultaneously enhance students' cognitive and social engagement. Thus, the GBL approach assisted by interactive digital media can serve as an alternative, innovative learning strategy that is relevant for supporting 21st-century physics education.

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