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The Effectiveness of the Application of the Virtual Lab-Assisted ARIAS Learning Model on Motion and Force Materials in Improving the Cognitive Learning Outcomes of Grade VII Students of SMPN 1 Bangko Pusako

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Abstract:

The low achievement of student learning outcomes is due to the lack of interest and activity of students in the learning process. Students do not understand the material and are not active during learning due to the monotonous learning model. This study is to describe and determine the effectiveness of the application of the ARIAS learning model combined with a virtual lab on motion and force materials in improving the cognitive learning outcomes of grade VII students of SMPN 1 Bangko Pusako. The study used a quasi-experiment approach with a Non-Equivalent Post-test Only Group Design. The sample consisted of two classes, namely the control class (28 students) and the experimental class (29 students). The research instrument is in the form of an objective test to determine students' cognitive learning outcomes. The data were analyzed through normality, homogeneity, and hypothesis tests. The results of the study stated that there was a significant difference in the cognitive learning outcomes of students in both classes. The average score of the experimental class was 71.7 (good category), and the control class got an average score of 53 (good category). After the Mann-Whitney U Test, a significance value of 0.000 (<0.05) was obtained, so it was concluded that the virtual lab-assisted ARIAS model was effective in improving students' cognitive learning outcomes on motion and force materials.

1. Introduction

Education is an important aspect of national development because it functions to improve the quality of the nation [1]. In the nature of the educational process, there are two main activities, namely learning and learning. Learning is a series of planned and systematic activities, including components such as educators, students, curriculum, methods, approaches, learning resources, facilities, and classroom management. Through learning, students are expected to develop knowledge, attitudes, and skills optimally [2].

The success of the learning process in schools is influenced by 2 main factors, namely teachers as teachers and students as students. Teachers play a role in designing, implementing, and evaluating learning, as well as providing the necessary assistance [3]. One of the duties of a professional teacher is to be able to create interesting and relevant learning. In this case, the selection of strategies and learning media is important so that the material can be delivered well. In some findings, the learning implemented by teachers still tends to be monotonous and less innovative, which has an impact on decreasing students' understanding and interest in learning [4]. However, various findings show that teachers have not been able to carry out interesting learning so that they cannot encourage the improvement of student learning outcomes. Learning that is less varied and tends to be monotonous results in students having difficulty understanding the material and becoming passive during learning activities. This problem can be overcome through the development of Natural Sciences (IPA) teaching and education.

Science learning should provide hands-on experience through observing, exploring, and understanding natural phenomena scientifically [5]. However, the use of science learning methods that are still traditional and less innovative make teachers not develop in teaching. This condition hinders the improvement of student understanding and has an impact on low learning outcomes. Therefore, there is a need for more powerful and diverse learning. Teachers must be able to sort out accurate learning models so that learning outcomes are improved, because the more accurate the model used, the better the learning process will be.

The results of interviews with science teachers at SMPN 1 Bangko Pusako show that in the material of motion and force, around 85% of grade VII students for the 2023/2024 school year obtained scores below KKM. A similar condition occurred in the 2024/2025 school year, where 78% of the 170 students have also not reached the KKM. The teacher said that the decline in students' understanding was caused by less varied learning models and limited use of supporting media. Grade VII students are in the transition period from elementary to junior high school, so they need more attention in learning activities. Motion and force materials are considered quite difficult because they have not been studied in depth before, so many students become less motivated and easily feel bored during learning.

The ARIAS learning model (Assurance, Relevance, Interest, Assessment, Satisfaction) is expected to be able to improve students' cognitive learning outcomes. This model can foster confidence, connect the material with student activities, and make the learning process more engaging. ARIAS is a development of the ARCS model (Attention, Relevance, Confidence, Satisfaction) introduced by John M. Keller (1987). However, ARCS has not included an element of assessment, even though evaluation is important to see the development and learning outcomes of students. Therefore, the ARIAS model adds an assessment component as an improvement. This model includes five parts, namely assurance, relevance, interest, assessment, and satisfaction [6].

Academic achievement is influenced by a number of interrelated factors, such as learning materials, classroom atmosphere, learning media and resources, and teachers' abilities. Learning outcomes can be hampered by weaknesses in any of these areas [7]. Learning media plays an important role in supporting students to explore the material, especially material that is imaginary and requires a deep understanding. One of the media that can support the understanding of science concepts is virtual lab. Virtual lab is a computer-based media that presents simulations of various activities or experiments that allow students to observe processes or reactions that are difficult to see directly in real conditions [8]. With the media virtual lab, laboratory limitations can be overcome by creating a learning environment for practicum activities. Due to the lack of laboratory facilities, the use of this medium is essential. Educational tools such as Virtual labs can help online learning, especially practicum activities, in addition to helping the progress of science and technology [9]. It is hoped that the use of virtual lab media such as PhET Simulation, The Physics Interactive, and virtual laboratories can make it easier for educators to deliver materials, so that learning time can be used more effectively and student learning outcomes increase. The use of the right learning strategies, including choosing appropriate media, can help students better understand the material and make the learning process more engaging and exciting [10].

Therefore, this study aims to describe the cognitive learning outcomes of students after using the ARIAS model combined with a virtual lab, as well as to find out how effective the model is in improving the learning outcomes of grade VII students of SMPN 1 Bangko Pusako on motion and force materials.

2. Method

This research uses a quantitative approach, namely the data obtained is numerical in nature. The method applied is a Quasi Experiment, which is research that aims to see the influence of a treatment on other variables but the research conditions cannot be completely controlled [11]. In the quasi experiment, the researcher still used two groups, but could not control all external factors that might affect the results of the study [12]. The essay used is Non-Equivalent Post-test Only Group Design, which is a design involving two groups, a treated experimental group and an untreated control group. The description of the research design can be seen in Table 1.

Table 1. *Non-equivalent post-test only group design [13]*

Group	Treatment	Post-test
Experimental Class	X	O_1
Control Class	-	O_2

With X showing a treatment in the form of learning with the ARIAS model supported by a virtual lab, O_1 is the result of a post-test in the experimental class, and O_2 is the result of a post-test in the control class.

The research was conducted on grade VII students of SMPN 1 Bangko Pusako. The implementation of the research during the odd semester of 2025/2026, starting in July 2025. The research population was the entire VII class, consisting of six classes with a total of 170 students. To determine the two classes that were sampled, the researcher conducted a normality test and a homogeneity test on the daily repetition value before studying the material of motion and force, namely the material of the essence of science and scientific method.

Table 2. *Cognitive instrument test profile*

No	Cognitive Domain	Number of Questions
1	Remembering (C1)	3
2	Understanding (C2)	3
3	Apply (C3)	3
4	Analyze (C4)	3
5	Evaluate (C5)	3
	Total	15

The research instrument consisted of learning tools and post-test questions in the form of multiple-choice questions totaling 15 questions with four answer options. The questions are arranged based on the revised

Bloom Taxonomy, covering cognitive levels C1 to C5. All indicators were compiled by researchers and adjusted to the competence of motion and force materials. Details of cognitive problems can be seen in Table 2.

Data analysis techniques are in the form of descriptive and inferential analysis. Descriptive analysis was carried out by processing the final score of the post-test which was then classified according to the category of cognitive achievement as listed in Table 3. For inferential analysis, a nonparametric Mann–Whitney U statistical test was used, considering that the data were not entirely normally distributed.

Table 3. *Categories of cognitive learning outcomes [14]*

Value Range	Categories of Cognitive Learning Outcomes
80 ≤ X ≤ 100	Very Good
60 ≤ X < 80	Good
40 ≤ X < 60	Satisfactory
20 ≤ X < 40	Fair
0 < X < 20	Poor

3. Results and Discussion

The data used in this study came from the results of post-tests on motion and force materials after the two classes received different learning treatments. The experimental class learned with the ARIAS model equipped with a virtual lab, while the control class used the usual learning methods. The tests given amounted to 15 multiple-choice questions and were arranged based on cognitive ability levels C1 to C5.

Based on the post-test results, a description of the cognitive learning outcomes of each class can be seen in Table 4.

Table 4. *Description of students cognitive learning outcomes by achievement category*

Interval (%)	Category	Experimental Class		Control Class	
		Number of Students	Percent (%)	Number of Students	Percent (%)
80 ≤ X ≤ 100	Very Good	7	24,1	4	14,2
60 ≤ X < 80	Good	21	72,4	7	25
40 ≤ X < 60	Satisfactory	1	3,4	10	35,7
20 ≤ X < 40	Fair	0	0	7	25
0 < X < 20	Poor	0	0	0	0
Average		71,7		53	
Category		Good		Satisfactory	

From the table, it can be seen that 96,5% of students in the experimental class were in the good and very good category, much higher than the control class which only reached 39,2%. In addition, 25% of the students in the control class were in the poor category, while the experimental class had no students in that category. This shows that the learning used in the experimental classroom has a more positive effect on student learning outcomes. A description of the results for each cognitive aspect can be seen in Table 5.

Table 5. *Description of students cognitive learning outcomes on each cognitive aspect*

No	Cognitive Level	Experimental Class		Control Class	
		Score	Category	Score	Category
1	Remembering (C1)	81,6	Very Good	67,8	Good
2	Understanding (C2)	75,9	Good	46,4	Satisfactory
3	Apply (C3)	71,3	Good	55,9	Satisfactory
4	Analyze (C4)	67,8	Good	47,6	Satisfactory
5	Evaluate (C5)	62,1	Good	47,6	Satisfactory
Average		71,7	Good	53	Satisfactory

Based on Table 5, it can be seen that the cognitive learning outcomes of students in the experimental class and the control class differ in each aspect. The experimental class scored higher on all cognitive aspects. The average score of the experimental class was 71.7 and was in the good category, while the control class got an average of 53 with a satisfactory category.

ARIAS learning model combined with the use of virtual lab proven to have a significant ability to improve students' cognitive learning outcomes. The improvement is achieved with a procedure that begins with a stage Insurance which aims to foster students' self-confidence as a prerequisite for learning readiness. Next, the stage Relevance The role of relating teaching materials to the factual context of daily life, which serves to trigger curiosity and focus students' attention. Innovative use of media at a Interest aims to maintain and increase interest in learning, so that students are actively involved in assignments. Phase Assessment Then provide constructive feedback on learning outcomes to encourage increased motivation to achieve. Finally, the stage Satisfaction Ensuring the strengthening of understanding through material conclusion activities, followed by evaluation of the learning process by teachers and the assignment of structured assignments to measure the level of mastery of concepts independently [15].

A more detailed explanation of cognitive abilities including remembering, understanding, applying, analyzing, and evaluating is presented in the following description.

1. Remembering (C1)

Remembering is an important component in repeating or re-mentioning knowledge or information stored in memory. The ability to re-recognize knowledge, facts, and ideas from previous experiences is included in the recall component [16]. The ARIAS model is able to help students well in remembering and understanding the material being studied [17]. ARIAS learning helps students achieve the aspect of remembering because they not only learn individually but also work in groups, so they indirectly repeat and recall what their teacher taught. With the help of the ARIAS model, the media virtual lab and LKPD are able to improve students' ability to read, remember, and understand concepts. This is especially true when students use LKPD together in a virtual lab to solve problems and answer questions. This process enhances social interaction and helps students remember ideas for a long time. In the early stages of learning, students are directed to re-recognize basic concepts of motion and force. Teachers use virtual lab media as a digital learning resource that displays explanations, animations, and interactive examples so that students can recall their initial knowledge of movement concepts. The display of the media used is presented in Figure 1.

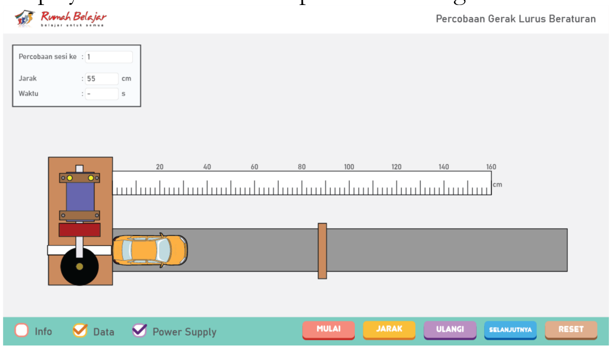

Figure 1. *Laboraatorium maya media display*

At the beginning of the learning activity, students conducted virtual experiments using virtual laboratory media to get to know the basic concepts of movement. At the beginning of the experiment activity, students were guided to open the link that had been previously given by the teacher using a mobile phone. After that, an initial view of the virtual lab will appear, which students will then be given a direction to click the cross button on the initial view of the virtual lab. Then, students were directed to fill in the distance according to the instructions in the LKPD as well as check the data and power supply to start experiment 1. Next, students will start experiment 1 by clicking start on the menu displayed by the virtual laboratory, then students will observe the movement of the car on a straight track and record the results of the experiment on the LKPD. Then, if the student does not understand the 1st experiment, students can click the repeat menu to repeat the 1st experiment. In the final stage, if in experiment 1 students already understand, then students can proceed to experiment 2 by clicking the next menu which will then display experiment 2 with a different distance from experiment 1. Through this virtual experiment activity, students were able to recall the basic concept of motion, stating that objects are said to move if their position changes to the reference point so that they can answer questions number 1 and 2 in the post-test questions. This experimental activity with the virtual laboratory makes it easier for students to connect between visual observations and theoretical concepts, so that at this stage students have achieved the C1 cognitive indicator, which is able to remember and reinterpret the concept of movement based on the results of experiments conducted in class.

This is similar to research [18] who said that learning using virtual laboratories improves teaching efficiency. Students also experience improved memory and show better material memory. These virtual labs have the ability to simplify complex scientific concepts so that students can understand them more easily. Virtual lab Help students remember and understand basic concepts more easily, so that they can improve their learning outcomes in the knowledge aspect.

2. Understanding (C2)

Comprehension involves the ability to interpret information through grouping and comparing activities. Grouping is done by organizing more specific information, while comparing aims to see the similarities and differences between two or more objects [19]. The results showed that the understanding ability (C2) of students in the experimental class was higher than that of the control class. The difference occurs because both classes use different learning models. Assisted ARIAS model virtual lab Help students in experimental classes understand the material through group learning, encouraging the exchange of ideas and mutual understanding. Students can complement each other with information they don't yet understand through these interactions.

In addition, LKPD and virtual lab allows students to conduct experiments, analyze results, and draw conclusions, which allows their understanding to actively develop rather than just memorize. In the learning that takes place, students will be guided to deepen their understanding of the material using virtual lab media such as the physics classroom: vector walk. In the virtual laboratory, especially motion materials, students can understand the concepts of distance and displacement through straight-motion simulations so that they are able to deepen students' understanding of the concept of learning materials. The display of the media used is presented in Figure 2.

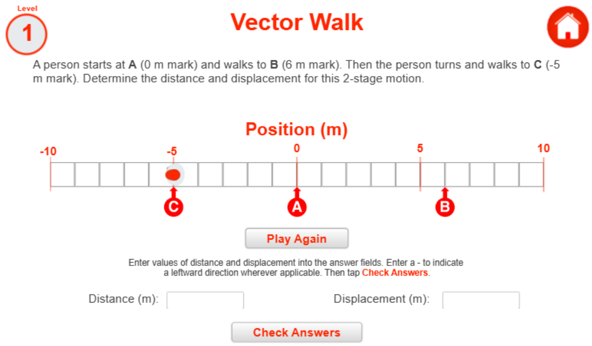

Figure 2. *The physics classroom media display: vector walk*

At the beginning of learning, learning activities are focused on training students' ability to understand the concepts of distance and displacement through virtual experiment activities using the physics classroom media. At the beginning of the experiment activity, students were directed to open a virtual media page through a link that had been sent by the teacher. Furthermore, if the initial view of the physics classroom media has appeared, then students are directed to click the start menu on the front view of the physics classroom: vector walk. Then, after clicking the start menu, students are instructed to fill in the name field with the name of the student or group. Next, students are given directions to choose level 1 which then students will click on the animation menu, after which an animation of objects or people moving in different directions and distances will appear. Then students are asked to observe the movement of objects or people and then if students still do not understand the movement of the object or person, students can repeat the animation by clicking play again. Furthermore, if the student has received an answer that he feels confident, the student is asked to answer the question on the LKPD and the column in the physics classroom: vector walk display to check the correctness of the answer that the student has written on the LKPD. The distance column is to calculate the distance traveled and the displacement column is to calculate the displacement of the object, then students are asked to click check answer to find out the correct answer of the question. If the answer is correct, then students are asked to continue the experiment according to the instructions in the LKPD by clicking on the next levels according to the instructions in the LKPD. Through this experimental activity, students showed an increase in their ability to understand the concepts of distance and displacement material, and were able to calculate the value of both based on the results of observations from the simulation so that students were able to answer questions number 3 and 4 in the post-test questions. Students not only see the movement of objects visually, but are also able to interpret the data that appears into the form of numbers through simple calculations. Therefore, learning using the physics classroom media at this stage helps students achieve the C2 cognitive indicator (comprehension), which is the ability to explain, interpret, and calculate distance and displacement based on the results of experiments conducted directly in virtual simulations

These findings are similar to research [20] which explains that the implementation of the discovery learning Supported by virtual laboratory media can increase students' mastery of physics concepts. This can be seen from the average score of mastering concepts that is too high in students who learn using assistance virtual lab compared to students who study with conventional methods. In other words, virtual labs help students understand the material more deeply because they can see, try, and explore concepts in a hands-on and interactive way.

3. Apply (C3)

Applying (C3) is the ability of students to use the knowledge and techniques that have been learned to solve problems or tasks. This ability includes applying an idea to a form of work, such as creating a model, presentation, simulation, or other ways to solve a problem [19]. The results showed that students got better learning outcomes in the experimental class than in the control class. This is due to the use of the virtual lab assisted ARIAS model, which allows students to use the material to solve problems. Students in this learning work in groups to solve problems that depend on their understanding of concepts through LKPD. On the other hand, lab virtual simulate real situations so that students can apply their understanding directly. Students can test ideas, follow procedures, and solve various problems through these activities. This activity is able to improve their ability to apply knowledge further than just remembering or understanding. In its application, PhET Simulation media is one of the media that is suitable for use. In simulations, students can change the magnitude of the force to see how it affects the resultant force at work. Through this activity, students not only understand theory, but are also able to apply it in real life in a virtual context. The display of the media used is presented in figure 3.

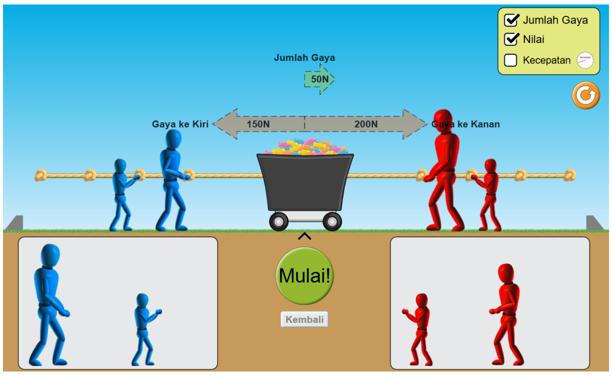

Figure 3. *Media display PhET Simulation: net force*

At the learning stage of motion and force materials, students conduct virtual experiment activities to train students to apply the concepts of motion and force materials, especially resultant forces using PhET Simulation: net force media. In the early stages of learning in conducting virtual experiments, students are asked to access the link that has been given by the teacher which will then display the media display as shown in Figure 3. Next, students are asked to check the columns of the forces and values, to find out the magnitude of the force and value given by the simulation object. Then, students will place the object on one side (right or left) according to the instructions in the LKPD. If the student has placed the requested object on the right side, then the student can click the start menu on the PhET Simulation to start the simulation. Then students are asked to observe the simulation carefully to see how the resultant force works which then results from the magnitude and direction of the resultant force recorded in the table provided in the LKPD. Furthermore, students will be directed to complete the observation table according to the instructions in the LKPD (Student Worksheet). During the activity, students discussed to interpret the results of the experiment and draw conclusions based on the data obtained from the simulation. This process trains students to think critically, analyze phenomena quantitatively, and understand how resultant forces are formed from several forces acting on objects so that students are able to answer question number 9 in the post-test question. Through this activity, students are able to apply the concept of resultant force in a more in-depth and contextual way, so that the knowledge gained can be the basis for application in daily life.

This is similar to research [21] which states that students can more easily apply the concepts they learn from a real environment by using a virtual lab combination without taking away students' scientific process skills. Virtual labs help students understand and apply knowledge by providing a safe and controlled environment where they can try out a variety of options and see results.

4. Analyze (C4)

Analyzing is the process of understanding a problem by separating its parts, then seeing how those parts are connected to each other to cause a problem. Analysis activities include the ability to distinguish, rearrange information, and explain the causes or relationships between these parts [19]. The findings of the study indicated that the level of students' ability to perform analysis (C4) in the experimental group was in a higher value range compared to the control group. This means that the analytical ability of students in the experimental class is better. The use of the ARIAS model combined with virtual lab It is also influential because it allows students to work together in solving problems. In the learning process, they not only work on their own questions, but also check each other, assess, and provide input on the answers of their group mates. This encourages students to conduct a more in-depth analysis of the problem, distinguish relevant information, and trace the logical relationship between the problems. Virtual lab It also enhances students' analytical abilities by allowing them to actively explore ideas, change variables, observe changes, and analyze relationships between variables. PhET Simulation media is one of the suitable media to use. In the simulation, students can change variables such as force, mass, and friction to see how they affect the acceleration of objects. The display of the media used is presented in Figure 4.

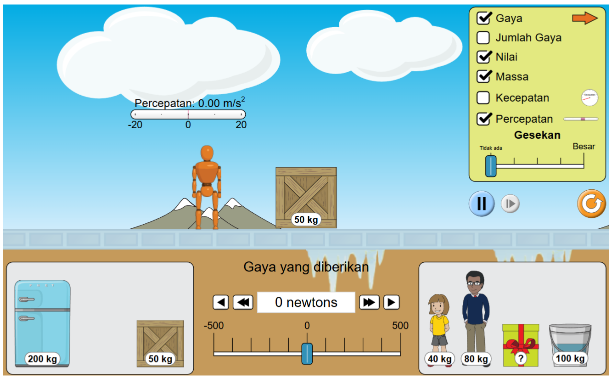

Figure 4. *Media display PhET Simulation: acceleration*

This is similar to research [22] which states that the use of virtual labs provides learning outcomes comparable to or even better than traditional labs. All categories of learning outcomes exhibit these benefits, including knowledge, comprehension, inquiry skills, practical skills, analytical skills, and scientific communication skills. Virtual labs help students learn analytically by providing them with an environment that allows them to process data freely. Students are trained to find patterns and cause-and-effect relationships by easily manipulating variables, conducting experiments again, and comparing results. This method directly improves the student's ability to draw more accurate conclusions.

5. Evaluate (C5)

Evaluating is the ability to provide assessments based on certain standards and criteria. Aspects that are commonly used as a reference in evaluation include quality, effectiveness, efficiency, and consistency. Evaluation activities include an examination process (checking) and critical review (critiquing) [19]. The results of the study show that the application of the ARIAS model is effective in improving students' evaluation skills through the use of virtual labs. The average value of the evaluating aspect (C5) in the experimental class was recorded to be too high compared to the control class. Students not only solve the questions independently, but also evaluate the answers in unison, find mistakes, and consider the reasons behind each answer, so they are accustomed to validating their understanding based on the correct concepts. Use virtual lab and LKPD speeds up this process because students can learn concepts directly, change variables, observe changes, and assess whether the results of the experiment match the theory. In the closing stage, students' ability to think critically, reflect, and draw scientific conclusions is increasingly developed through the activity of comparing the results of simulations between groups. In the final stage, students are asked to evaluate the results of the virtual experiment by comparing the results of the group simulation. This activity aims to foster students' critical and reflective thinking skills towards the concepts learned. Through this evaluation, students can draw scientific conclusions based on the data obtained from the simulation. The media display of the PhET Simulation is shown in Figure 5.

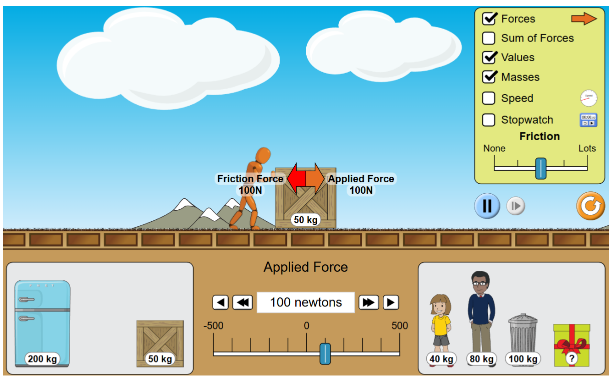

Figure 5. *Media display PhET Simulation: friction*

At the stage of the core learning activity, students practice the ability to evaluate the concept of Newton's Law III through experiments using the media PhET Simulation: friction. The initial activity of the experiment, students were asked to access the link that had been given by the teacher before the experiment. Then students are asked to check the force, grade, and mass without changing the friction. Furthermore, students will be directed to employ the methodology prescribed in the LKPD. Then the student pays attention to the force of action given by the person to the box and the reaction force given by the box to the person whose results can then be recorded on the observation table, then compare them to make sure that the action force and the reaction force have the same magnitude but opposite directions, in accordance with the principle of Newton's Law III. Students are asked to change the size of the force in accordance with the LKPD and observe the events that occur in the simulation carried out so that the results of the next observations are recorded on the observation table in the LKPD. Through this activity, students learn to identify action-reaction force pairs in a real-world context, which prepares them to answer question 15 on the post-test, so that their understanding of the application of Newton's Law III becomes clearer, simpler, and more meaningful. These findings These findings align with Najib's research, which demonstrated that using virtual lab-based learning tools enhances students' content mastery and critical thinking skills [23]. This can be seen from the increase in the average value Pre-test and post-test. N-gain critical thinking ability reaches 0.35 which is in the medium category, while N-gain mastery of the concept of 0.14 which is in the low category.

4. Conclusion

The results showed that the use of the ARIAS learning model combined with the virtual lab on motion and force materials could significantly improve students' cognitive learning outcomes. This can be seen from the average post-test score that reached the good category after participating in learning. In addition, there is a significant difference between classes with virtual lab-assisted ARIAS models and classes applying conventional methods. Based on post-test scores, classes with virtual lab-assisted ARIAS models are in the good category, while classes with conventional learning are categorized as satisfactory. Thus, the virtual lab-assisted ARIAS model was declared effective in improving students' cognitive learning outcomes on motion and force materials. Based on this conclusion, it is suggested that the ARIAS learning model combined with the virtual lab can be used as an alternative learning strategy in science subjects, especially in physics materials in schools. Further research is recommended to apply the virtual lab-assisted ARIAS model to different materials, other levels of education, or with more diverse research variables. The goal is that learning innovations can continue to be developed and the quality of the student learning process is increasing.

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