Vol. 15, No. 04, pp. 2234-2257, 2025 DOI: 10.23960/jpp.v15i4.pp2234-2257

Jurnal Pendidikan Progresif

e-ISSN: 2550-1313 | p-ISSN: 2087-9849
http://jpp.fkip.unila.ac.id/index.php/jpp/

The Effect of Physics Modeling Learning Module to Improve Science Generic Skills on Momentum and Impulse Topics

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Received: 28 July 2025 *Accepted: 04 September 2025* *Published: 30 October 2025*

Abstract: The Effect of Physics Modeling Learning Module to Improve Science Generic Skills on Momentum and Impulse Topics. The learning process dominated by lectures and the use of conventional teaching materials that are difficult for students to understand leads to low generic science skills in students. One-way, teacher-centered learning causes students to become passive. Meanwhile, abstract and quantitative material on momentum and impulse requires a conceptual and visual approach to make it easier for students to understand. **Objectives:** This study aims to determine the impact of using physics modeling learning modules on the improvement of generic science skills in impulse and momentum material. **Methods:** This study employed a quasi-experimental design with a one-group pre-test and post-test approach, applied to 34 students in class X.1, who served as research subjects at SMA Negeri 1 Alalak. The data were analyzed using n-gain scores and a paired sample t-test to determine the magnitude of the effect before and after treatment was administered. **Findings:** The analysis reveals that the use of effective physics modeling learning modules can enhance generic science skills, yielding an n-gain of 0.81. A substantial difference between the conditions before and after using the physics modeling learning module is also evident in the results of the paired sample t-test, which demonstrates how using the module affects students' development of generic science skills. **Conclusion:** Physics modeling learning modules have significantly and successfully enhanced students' generic science skills related to momentum and impulse content.

Keywords: impulse, module, momentum, physics modeling learning, science, generic skills.

To cite this article:

Arifuddin, M., Fadillah, M. R., & Mahardika, A. I. (2025). The Effect of Physics Modeling Learning Module to Improve Science Generic Skills on Momentum and Impulse Topics. *Jurnal Pendidikan Progresif*, *15*(4), 2234-2257. doi: 10.23960/jpp.v15i4.pp2234-2257.

INTRODUCTION

Physics is a branch of science or natural sciences (Bhakti et al., 2023). Physics studies the laws of the outside world, which are universal and independent of outsiders (Lyahov, 2025). In this discipline, emphasis is placed on the thinking skills approach, with the hope that students can be active in finding facts, building theories, and developing scientific attitudes. This helps learners develop their competencies, including generic science skills (Pamungkas & Wardani, 2024). Generic science skills refer to intellectual competencies that emerge from the integration or interaction of scientific knowledge and scientific skills (Setiawan et al., 2023). Generic science skills are fundamental skills required to train students in scientific work, enabling them to understand concepts, solve problems, and perform other scientific activities, as well as learn independently, effectively, and efficiently (Brotosiswoyo, 2001). These abilities are broad in scope and can be enhanced as learners progress through the educational process (Hayati et al., 2021). Nine generic science skills can be developed through physics learning. These aspects include direct observation, indirect observation, awareness of scale, symbolic language, logical frameworks, logical consistency, cause-and-effect laws, mathematical modeling, and concept building (Lestari et al., 2024). These abilities are crucial for preparing students to participate in scientific activities, comprehend ideas, use scientific methods to solve problems, and learn efficiently and independently (Hutabarat & Sinaga, 2024). These skills must be developed and improved early, especially for high school (SMA) students (Sarita & Kurniawati, 2020). The reason for this is that students may apply theory to the real world by using generic science abilities to comprehend and grasp more complex scientific topics (Kurniawan & Nawahdani, 2024).

However, in practice, students' generic science skills are still relatively inadequate. This statement is supported by interviews conducted by Pitri et al. (2024) at a public high school in Aceh, which showed that many students lacked interest in physics lessons. Students perceive physics as a complex subject, particularly due to its connection with mathematical formulas, where mathematical explanations are often prioritized. As a result, most of the time is spent on problem-solving rather than understanding the underlying physical phenomena. Additionally, teachers continue to employ conventional models with teacher-centered learning processes that do not sufficiently engage students in the learning process. This causes students to become bored while learning, resulting in poor learning outcomes. This also occurs because students still lack the development of generic science skills during learning activities. Interviews with Pamungkas & Wardani (2024) at a state Islamic high school in Surakarta corroborate this assessment, highlighting several concerns about the curriculum, instructional resources, and the educational process. In terms of content, the physics curriculum is considered too broad, containing abstract concepts that are difficult to understand and an excessive number of equations. Regarding teaching materials, commercial resources that are difficult for students to understand are used. The learning experience is dull and uninspiring, primarily because it relies heavily on lectures and lacks hands-on exercises. This approach enables pupils to learn passively by listening to the material, taking notes on what they hear, and answering practice problems based on the given examples.

Students also do not really want to study physics or are not particularly interested in it. The primary reason for this is that students' willingness to study physics is diminished by their insufficient general scientific abilities in the classroom (Halim et al., 2020). Mbata et al. (2025) also suggest that students struggle in physics because they are unable to retain and apply the practical skills necessary for conducting experiments. Bahtaji et al. (2023) assert that the tenuous correlation between scientific engagement and understanding physics ideas may stem from the situational and contextual characteristics of physics challenges. These problems ultimately lead to inadequate general scientific skills among pupils. Students struggle to articulate and apply the ideas they have been taught in real-life situations due to insufficient learning activities that integrate theoretical knowledge and limited opportunities for practical experience (Majid & Atan). For students to effectively utilize both empirical experience and reasoning to comprehend concepts, they must be taught to employ reasoning when grasping these concepts (Dania & Taufiq, 2021). Furthermore, a strategy for developing generic science abilities is necessary since, as stated by Kartika et al. (2021), these skills offer knowledge that may be used in a variety of scientific occupations.

Students' generic science abilities can be significantly enhanced using the right learning strategy, as these skills fundamentally depend on conceptual understanding and problem-solving abilities (Salma et al., 2023). Prima et al. (2024) define a learning model as an organized framework that systematically describes the steps involved in the educational process in order to facilitate the achievement of learning objectives. Additionally, effective learning must be supported by suitable teaching materials. Teaching materials serve as educational resources for teachers and students, acting as a medium that supports the learning process. Various teaching materials are available, including worksheets, modules, textbooks, exercise sheets, and others, each with unique characteristics that can help educators deliver learning materials (Fitri et al., 2023). Because the content in modules is customized to each student's needs and allows for self-directed learning, using instructional materials in the form of modules has proven to be very advantageous for educators when delivering knowledge to students (Haka et al., 2020). Self-directed learning empowers students by giving them choices and responsibility in their educational journey (Houghton, 2023). One learning model considered highly suitable for module implementation is the physics-based learning model.

One instructional model that incorporates physics modeling methods into the teaching and learning process is the Physics Learning Model (P2F). According to this model, physics education is conducted using established mathematical formulas and fundamental physics principles to create visual models based on observable physical phenomena, and employing mathematical reasoning to derive predictive formulas related to those phenomena (Arifuddin et al., 2022). Modeling in physics learning is essential because it encompasses the fundamental or basic skills students require to learn physics (Sari, 2020). Learning physics using modeling can improve students' understanding of concepts. Understanding concepts is very important in learning so that students can apply these concepts to solve physics problems for learning success (Wahyuni et al., 2024). Modeling learning emphasizes the use of models to explain a phenomenon and can help students understand the concepts of physical phenomena that occur in daily life. It is anticipated that this modeled learning will provide students with a clearer understanding of the concepts.

The learning theories that encourage physics models in learning, according to Arifuddin et al. (2022), include Albert Bandura's Social Learning Theory, Piaget's Developmental Theory, Bruner's Learning Theory, and David Ausubel's Theory. The physics modeling learning model is in line with Bandura's social learning theory through observation and imitation in building models, supports Piaget's formal cognitive development stage by developing abstract thinking skills, reflects Bruner's principle of discovery learning from concrete to symbolic representations, and reinforces Ausubel's meaningful learning through linking new knowledge with previously acquired physics concepts. It has been demonstrated that physics modeling learning (P2F) satisfies the requirements for efficacy, validity, and the capacity to foster scientific abilities (Arifuddin et al., 2022). Based on previous studies, there has been no research specifically focusing on generic science skills. However, these skills play an important role in supporting the learning process, especially in physics, as they can help students better understand scientific concepts (Doyan et al., 2024).

Therefore, it is crucial to utilize teaching materials as modules that incorporate physics modeling learning to overcome today's obstacles. This is especially true for those who intend to improve generic science abilities in the context of themes related to momentum and impulse. This study assesses how employing physics modeling learning modules can enhance generic scientific knowledge on momentum and impulse content.

METHOD

Participant

Thirty-four students from class XI.1 at SMA Negeri 1 Alalak for the 2024–2025 academic year participated in the trial for this study. In the meantime, the data collection method was derived from the learning outcome test results, which were collected by students as pre-tests and post-tests.

Research Design and Procedures

This study was conducted using a quasi-experimental design. The implementation design in this study employed a one-group pre-test post-test design, which served as the basis for comparing conditions before and after treatment through the use of physics modeling learning modules. The study commenced in March 2025 and concluded in April 2025. The module needs to be dependable and legitimate before it can be utilized for instruction. The validation sheet, which is evaluated by three validators, shows the module's validity. From there, you may find out how reliable the module is. Once the module has been verified as authentic and reliable, it may be used in the learning process.

Before treatment, students were administered a pre-exam with questions about what they had learned to assess their prior knowledge of science, before they used the physics modeling learning module. After gathering data from the students' pre-test scores, three lessons were held using the physics modeling learning module. We discussed momentum, impulse, and their connection during the first meeting. We discussed about the law of momentum during the second meeting. The third meeting was on various types of collisions. This is done to help pupils improve their general scientific skills by employing physics modeling learning modules. After treatment, students took a test to assess their understanding of general science using the physics modeling learning module. This test was meant to determine how well the kids had learnt. After collecting the students' pre- and post-test scores, the data were examined to determined the effectiveness.

Instrument

Tests were conducted before and after the research tools were used, utilizing sheets to verify the results of learning and ensure that the physics modeling learning modules were accurate. The module validation assessment tool is a checklist that consists of four steps for evaluation. Validators need to check a variety of things about this instrument, such as how it appears and what it says. We get the average score for each component of the test to gather the data from the validation results. The findings of the computation were changed to meet the module's validity standards, which were based on Widyoko (2019). These were the groups: very good for value $X > 3.4$, good for value $2.8 < X \leq 3.4$, good enough for value $2.2 < X \leq 2.8$, not very good for value $1.6 < X \leq 2.2$, and not good for value $X < 1.6$. Makhrus et al. (2020) also note that the percentage of agreement (PA) equation is used to see how well the assessments from multiple validators match up to see whether the module is reliable. A module is deemed reliable if its reliability value is above 75%.

The physics modeling learning module has been demonstrated to be both valid and reliable, as evidenced by the outcomes of the module's validity and reliability assessment. When the content and display of a module pass validation and fall at least into the good category, the module is considered legitimate. The module's overall reliability coefficient was 91.77% with the reliability category, and its overall validity average score was 3.64 with the excellent category. This demonstrates that the module's efficacy may be evaluated.

Aspects of general science abilities were developed using the learning outcome test instrument, which consisted of pre-test and post-test essay questions totaling nine questions on the topic of momentum and impulse material. Each question includes one facet of a general science skill. According to Brotosiswoyo (2001), this study examines several generic science skills, including direct and indirect observation, scale awareness, symbolic language, logical framework, logical consistency, the law of cause and effect, mathematical modeling, and concept building.

Direct Observation

Using sensory instruments to observe objects directly is known as direct observation. This component involves pupils using their senses to see physical events in pictures, such as a karate practitioner using his fist to smash concrete blocks. Additionally, students gather information from the outcomes of physical phenomena and provide the identification results depending on the results they have obtained.

1. Observe the phenomenon that occursin the attraction of a karate athlete breaking a concrete block in the following image!

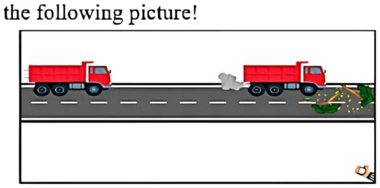
Based on the image, identify the phenomenon that occurred based on the facts found and explain why the block can break when hit by a karate athlete.

Figure 1. Question number 1 on the aspect of direct observation

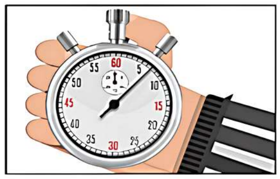
Indirect Observation

Due to the limitations of human sensory tools for direct observation, indirect observation is observation carried out with the use of measuring devices or other help. In this area, students use measuring devices as sensory aids to observe physical phenomena. For example, they use analog stopwatches to measure how long it takes trucks to brake by reading the designation scale on the device. Students can also gather current information from the outcomes of physical phenomena.

2. Take a look at the following picture!



There was a truck with a mass of 5,000 kg moving at a speed of 14 m/s on the highway. Suddenly, the driver saw a fallen tree branch in the middle of the road and immediately braked to stop the truck from hitting the branch. Then on the side of the road, a child using an analog stopwatch tries to measure the time it takes for the truck to stop completely. After the measurement, the child gets the results as shown in the following image.



Based on the image, determine how much time the truck travels during braking on the analog stopwatch designation scale!

Figure 2. Question number 2 on the aspect of indirect observation

Awareness of Scale

The capacity to compare the sizes of two distinct items is known as awareness of scale. As demonstrated by the phenomenon of two objects passing on the highway with different masses and speeds, such as trucks and bicycles, students are aware of natural objects that exist and are highly sensitive to numerical scales as quantities or measures on both the microscopic and macroscopic scales. Students also responded that the momentum produced can be impacted by the differences in mass and speed scales between bicycles and vehicles.

Symbolic Language

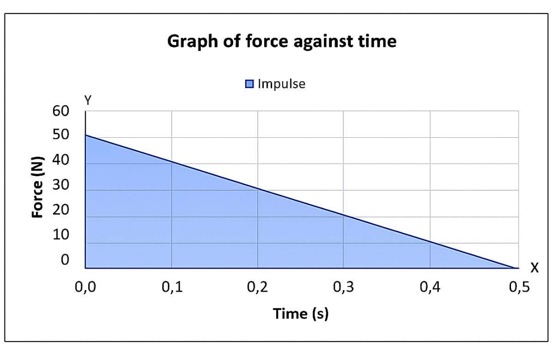
Symbolic language is the ability to understand the meaning of symbols in the world of science. In this aspect, students understand

3. A truck with a mass of 8,000 kg drove on the highway at a speed of 20 m/s. Then in another lane, a bicycle with a mass of 8 kg drove at a speed of 2 m/s. Based on this information, answer the following questions:
   a. Count the momentum on the truck and the bike, respectively!
   b. Explain how the difference in mass and speed scales between trucks and bikes can affect the momentum value of both!

Figure 3. Question number 3 on the aspect of awareness of scale

symbols, terms, and equations in physics, understand the quantitative meaning of units and quantities of an equation, and use mathematical rules in solving problems or physical phenomena that occur. In addition, students read a graph of the phenomenon that occurred, which is in the form of a force graph against time on the phenomenon of a soccer player kicking a stationary ball at a certain speed and contact time.

4. A soccer player kicks a ball that initially stands still with the speed and time of contact between the player's foot and the ball as shown in the graph belo



Based on the graph, calculate the impulses acting on the ball!

Figure 4. Question number 4 on the aspect of symbolic language

Logic Framework

The ability to develop a framework of thought and identify connections between two or more items is known as logical reasoning. In this area, students solve physics problems by searching for a logical connection between two rules, specifically using the example of a car traveling on a highway under two different speed conditions. In addition, students use the logical relationship they discovered when solving the issue to describe how the two-speed circumstanc changed the momentum created.

5. A car with a mass of 1,000 kg moves at a speed of 20 m/s on the highway. If the speed of the car is increased to 40 m/s, compare the momentum the car has at both speed conditions and explain how the change in speed affects the momentum of the car!

Figure 5. Question number 5 on the aspect of the logical framework

Logical Consistency

A conclusion that makes sense in light of the information gathered is known as logical consistency. In this area, students comprehend the guidelines and use them to clarify situations. To answer the question of which mode of transportation has the most momentum based on the table of different modes of transportation, students argue according to the rules. Additionally, students use rules to draw conclusions about physical phenomena, specifically based on the outcomes of physics problems.

6. There is a study conducted to analyze the momentum of various means of transportation in a city. The results of the study record the data obtained in the following table.

No.	Tool Transportation	Mass (kg)	Speed (m/s)	Momentum (kg. m/s)
1.	Car	1.000	70	70.000
2.	Bicycle	20	10	200
3.	Bus	3.000	20	60.000
4.	Motorbike	100	50	5.000
5.	Truck	5.000	10	50.000

Based on the table, answer the following questions:

a. Which means of transport has the greatest momentum? Give your arguments!

b. Draw conclusions based on the results obtained!

Figure 6. Question number 6 on the aspect of logical consistency

Law of Cause and Effect

The relationship between the different elements and scientific phenomena that comprise the relationship is known as the law of cause and effect. Students estimate the cause of physical phenomena in this aspect. Additionally, using a table of different modes of transportation, students formulate a hypothesis or short-term conjecture to estimate the relationship between two variables, such as mass and velocity, and the resulting momentum, in order to explain the relationship between two or more variables in a physical phenomenon.

Mathematical Modeling

A formula that uses mathematical language to express the quantitative and qualitative laws of natural occurrences is known as mathematical

7. There are five means of transportation with each having its own mass and speed as listed in the following table.

No.	Tool Transportation	Mass (kg)	Speed (m/s)
1.	Bicycle	20	10
2.	Motorbike	100	10
3.	Car	1.000	10
4.	Bus	3.000	10
5.	Truck	5.000	10

Based on the table, make a hypothesis or provisional conjecture regarding the variable relationship between mass and velocity to the momentum that will be generated in each means of transportation!

Figure 7. Question number 7 on the legal aspect of cause and effect

modeling. Students used sketches and formulas to depict phenomena and difficulties in this area. Specifically, they simulated the physical situation by creating sketches of phenomena on spheres A and B, both before and after a collision. Additionally, students offer different approaches, such as suggesting the correct formula to solve problems involving the calculation of the post-impact speeds of the two balls.

Building a Concept

Concept building involves enhancing the understanding of an object or process to comprehend a natural phenomenon that everyday language cannot adequately explain. In this regard, students create new concepts by expanding ideas related to a physical phenomenon, specifically by examining the behavior of iron balls dropped on two distinct surfaces. Students assess how the surface elasticity/restitution coefficient affects the kinetic energy produced following an impact. Students additionally elaborated on the connection between kinetic energy post-impact and the height of the rebound observed on both surfaces, drawing on analysis results and the interplay of concepts related to the phenomenon.

8. On a playing field there are two balls, namely ball A and ball B with a mass of 1 kg each. Ball A moves at a speed of 5 m/s to the right, while ball B moves at a speed of -3 m/s to the left. The two balls then collide with each other and move together after the collision at the same speed in the right direction.

   Question:

   a. Sketch out a picture showing the physical situation of ball A and ball B before and after the collision! Include a description of the mass of each ball and show the direction of its speed in the image!

   b. Calculate the speed of both balls after the impact!

Figure 8. Question number 8 on the aspect of mathematical modeling

Data Analysis

To examine the degree of students' general science skills, learning outcome assessment tools, including pre-tests and post-tests on momentum and impulse topics, were used to analyze test

9. A 2 kg mass iron ball is dropped from a height of 5 m onto two different types of surfaces, namely ceramic and sand. Ceramic surfaces have a restitution coefficient ($e = 0{,}8$), while sand surfaces have a restitution coefficient ($e = 0{,}2$). After the impact:
   - On a ceramic surface, the ball bounces at a speed of 8 $\mathrm{m/s}$.
   - On the surface of the sand, the ball bounces at a speed of 2 $\mathrm{m/s}$.

   Based on this information, answer the following questions:

   a. Analyze the effect of surface elasticity (restitution coefficient) on the kinetic energy of the iron ball left after the impact!

   b. Explain the relationship between the kinetic energy of the iron ball after an impact and its reflected height! Use energy conversion concepts/other relevant physics concepts to support your answers!

Figure 9. Question number 9 on the aspect of building a concept

results. Assessment guidelines or scientific generic skills assessment rubrics are used to evaluate students' learning outcome exam scores. The data from the learning outcome test was then calculated using a normalized gain score. The results of the calculation were adjusted to the n-gain category according to Hake (1999) which included the categories of high for value $(\langle g \rangle) \geq 0.7$, medium for value $0.7 > (\langle g \rangle) \geq 0.3$, and low for value $(\langle g \rangle) < 0.3$. A module is considered adequate if the n-gain value for generic science skills reaches a minimum of 0.3.

The pre-test and post-test results were analyzed to determine the improvement of students' generic science skills before and after the module was implemented through model-based learning. This study will use the Paired Sample T-Test with a tool for statistical analysis, SPSS (Statistical Package for the Social Sciences), particularly in the context of education. Both parametric and non-parametric statistical hypothesis tests are available in SPSS, as noted by Sharma & Jha (2023). The main prerequisite for the Paired T-Test, which falls under the category of parametric statistics, is that the study data must have a normal distribution. If the data is not distributed normally, the Wilcoxon Test, a non-parametric statistical analysis tool, can be employed instead of the Paired-Sample T-Test (Setyaedhi, 2025). Using SPSS, a normality test will be performed using the Kolmogorov-Smirnov method to determine whether the data have a normal distribution. Examining the significance value is one step in the Kolmogorov-Smirnov normality test decision-making process. If the significance value (Sig.) is greater than 0.05, the study data are considered to have a normal distribution; if the Sig. is less than 0.05, the research data are considered not to have a normal distribution.

The assessment of significant results also forms the foundation for choices in the context of the Paired Sample T-test. The means of matched samples are compared using the matched Sample T-test. Suppose the significance value (Sig. 2-tailed) is higher than 0.05, which indicates no appreciable change between the data collected before and after the intervention is found. The null hypothesis (Ho) is accepted, and the alternative hypothesis (Ha) is rejected. However, suppose the significance value (Sig. 2-tailed) is less than 0.05, indicating a significant difference between the pre-test and post-test data. In that case, the alternative hypothesis (Ha) is accepted and the null hypothesis (Ho) is rejected (Ulfah et al., 2024). The significant value (Sig.) of 0.200, which is higher than 0.05, shows that, based on the findings of the normality test, the pre-test and post-test data in this study are typically distributed. Thus, the Paired-Sample T-Test can be used effectively.

The generic science skills employed in this study include direct observation, indirect observation, awareness of scale, symbolic language, understanding of cause-and-effect laws, mathematical modeling, and concept building. Each question in the learning outcome test instrument, which consists of nine essay questions, includes aspects of generic science skills in each question. The achievement of generic science skills is reviewed based on the learning outcome test results, which include pre-test and post-test scores for each aspect of generic science skills obtained by students. The results of these calculations are adjusted to the criteria in the following table.

Table 1. Generic science skills criteria

No.	Value Interval	Criterion
1.	$81 < N \leq 100$	Highly Skilled
2.	$61 < N \leq 80$	Skilled
3.	$41 < N \leq 60$	Quite Skilled
4.	$21 < N \leq 40$	Less Skilled
5.	$0 < N \leq 20$	Unskilled

(Adaptation: Salma et al., 2023)

■ RESULT AND DISCUSSION

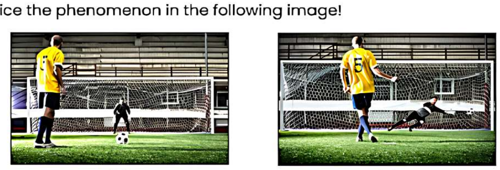
Implementation of Physics Modeling Learning Module

Modules created in line with the syntax or phases of physics modeling learning (P2F) are used in this study. There are various phases in the learning process for physics modeling, namely: 1) presentation and identification of problems related to physical phenomena, 2) provision of prerequisite information, 3) development of a physics model, 4) identification of solutions, and 5) evaluation of the process and results (Arifuddin et al., 2022).

In phase 1, which involves raising and identifying issues related to physical phenomena, educators present physical phenomena depicted in pictures. Students were then assigned to observe and identify these phenomena. In the first meeting, the educator presented a physics phenomenon in which a soccer player kicked a stationary ball, causing it to move. In the second meeting, the educator presented a physics phenomenon in which two billiard balls moved and collided with each other. In the third meeting, the educator presented a physics phenomenon in which a marble was released to hit another stationary marble as a target. Students' generic science skills, particularly in terms of firsthand observation, are significantly enhanced during this period.

Phase 1. Submission and Identification of Physical Phenomena Problems

Football is a sport that involves a situation where a player has to kick the ball to score. Notice the phenomenon in the following image!



(a) (b)

Figure 1. (a). The ball before it is kicked by the player. (b). The ball after being kicked by the player.
Source: istockphoto.com

When in a penalty situation, a player will kick a stationary ball with style on his feet to be able to score a goal into the opponent's goal. If the ball is kicked by the player, then what causes the ball that was initially stationary to move after being kicked? Then how does the force exerted and the duration of contact between the foot and the ball affect the movement of the ball after being kicked?

Let's identify the physical phenomena that occur. *Let's go!*
The more identification you do, the more your generic science skills will improve in terms **of direct observation.**

- The ball becomes moving after being kicked
- ....
- ....

Figure 10. The first phase of P2F on the module

Based on Phase 2, which provides prerequisite knowledge, educators and students jointly discuss the concepts that must be understood before entering the learning material. Then, students were asked to read the information in the module. This method helps pupils grasp the concepts more clearly.

Based on Phase 3, physical modeling comprises several stages, including physical modeling in image form, mathematical modeling in mathematical form, and experimental modeling in experimental form.

Phase 2. Provision of Prerequisite Information

Prerequisite Knowledge

- Motion is a change in the speed of an object that occurs due to the force acting on the object in a certain interval of time.
- Force is an attraction or impulse that causes a mass object to undergo a change in the state of motion and speed.
- Mass is a measure of the amount of matter contained in an object.
- Speed is a measure of how fast an object can move per unit of time.
- The initial velocity is the speed of an object before it is given a force.
- The final velocity is the speed of an object after being given a force.
- The change in speed is the difference between the final velocity of the object and the initial velocity of the object.
- Contact time is the time when a force acts on an object during direct interaction with another object causing a change in velocity.

Figure 11. The second phase of P2F on the module

Based on Figure 12, the physical modeling in images, students were asked to model the physical phenomena proposed in phase 1 into images. In each meeting, students completed the drawing by writing down what physical symbols were involved in the proposed physical phenomena. In the first session, students completed drawings depicting a player kicking a stationary ball. In the second session, students completed drawings depicting two billiard balls colliding with each other. In the third session, students were asked to complete drawings depicting a marble hitting another stationary marble as a target. Students' generic science abilities are also improved throughout this time, especially when using symbolic language.

Phase 3. Physics Modeling

Physical Modeling in Picture Form

The phenomenon of players kicking the ball in Figure 1. It can be modeled in the form of a physical image so that it can be analyzed related to what are the physical magnitudes involved in the phenomenon.

Let's complete the physical symbols involved. *Let's go!*
The more complete the physical symbols you write, the more your generic science skills in the aspect **of symbolic language will improve.**

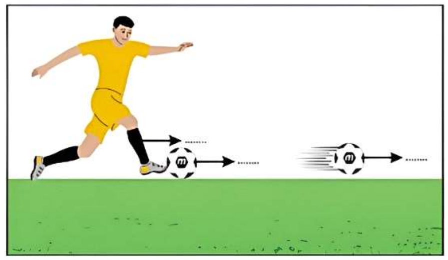


Figure 2. Picture model of the phenomenon of players kicking the ball
Source: personal documentation

Figure 12. Physical modeling in the form of images

Based on Figure 13, in the physical modeling process, students are asked to represent the physical phenomena proposed in Phase 1 in mathematical form. At each meeting, students were asked to write down physics equations based on their analysis of observed physical phenomena. Additionally, this period helps students enhance their generic science skills, especially in mathematical modeling. Based on Figure 14. In physical modeling in experiments, students asked to model the physical phenomena proposed in phase 1 in the form of experiments.

Physical Modeling in Mathematical Form

Based on the physical model in Figure 2. It can be derived from several mathematical formulas such as momentum, impulse, and the relationship between momentum and impulse.

Momentum

Momentum can be said to be the level of difficulty to stop the motion of an object, so every moving object must have momentum. Momentum ($\vec{p}$) defined as the result of multiplication between the masses of an object (m) with the speed of the object ($\vec{v}$). Momentum is directly proportional to the mass and Velocity of objects. Momentum also includes the vector quantity whose direction is equal to the direction of the object's velocity.

Let's write the equation in mathematical form. _Let's go!_
The more complete the equations you write, the more your generic science skills will improve in the aspect **of mathematical modeling.**

- **Momentum Equation**

$$\boxed{\ldots\ldots = \ldots\ldots \times \ldots\ldots}$$

Information:
$\vec{p}$ = Momentum $(\mathrm{kg.m/s})$
m = Mass of Objects (kg)
$\vec{v}$ = Velocity of objects $(\mathrm{m/s})$

Figure 13. Physical modeling in mathematical form

Physical Modeling in Experimental Form

Based on the mathematical formula that has been obtained, a simple experiment can be carried out to test empirically the formula.

Purpose of the Experiment

- Analyze the relationship between the mass of the object and the change in the velocity of the object to the change in the momentum of the object.

Tools and Materials
PhET Interactive Simulations *mobile and app*

Problem Formulation
Let's formulate the problem from the experiment. *Let's go!*
The more complete the formulation of the problem you write, the more your generic science skills in the aspect of **logic framework will improve.**

- "How is the relationship ....?"

Experimental Hypothesis
Let's make a hypothesis from the experiment. *Let's go!*
The more complete the hypothesis you write, the more your generic science skills in the law of **cause and effect will improve.**

- If it gets .... the mass of the object and the change in the speed of the object, the more .... changes in the momentum of objects.

Trial Steps
Let's observe the experiment using *PhET. Let's go!*
The more thorough the observations you observe, the more your generic science skills in the aspect **of indirect observation will improve.**

1. The first step, please open *the PhET* app or scan the *barcode* below using a *smartphone.*

SCAN KODE QR

Figure 14. Physical modeling in experimental form

At each meeting, students were asked to formulate problems, develop experimental hypotheses, and conduct experiments using PhET Simulations. At the first meeting, students were asked to conduct experiments to analyze the relationship between the mass of an object and changes in its velocity in relation to changes in its momentum. In the second session, students were asked to conduct an experiment to analyze the relationship between the initial total momentum of an object before a collision and its final total momentum after the collision, and to determine whether the law of conservation of momentum applies based on the experimental results. In the third session, students conduct an experiment to prove whether the law of conservation of momentum applies to all types of collisions based on the experimental results.

In this phase, students were asked to formulate problems from the experiments to be carried out. Additionally, this period helps students develop their generic science skills, particularly in the area of logical framework. In this phase, students are asked to formulate a hypothesis or temporary conjecture based on the experiment to be conducted. This phase further enhances students' generic science skills, particularly in relation to logical frameworks. Students are encouraged to conduct collaborative experiments using media such as PhET to observe physical phenomena during this phase. Furthermore, this stage supports the development of pupils' generic science skills, particularly in the area of indirect observation.

Based on phase 4. Looking for solutions, students were asked to process and analyze data from the experiment's results, make experimental conclusions, and work on consolidation problems for each meeting.

According to Figure 15, during the data processing stage of the experiment, students were required to accurately record and calculate the data obtained from the experiment, which will serve as material for analysis to answer the

Phase 4. Finding a Solution

After planning and conducting the experiment, then analyze the data from the experiment and discuss the results obtained.

Trial Data

Let's record and calculate the data from the experiment. *Let's go!*

The more accurate the data you record and calculate, the more your generic science skills will improve in terms **of awareness of scale.**

Table 1. Experimental Observation Results

No.	Mass (kg)	Speed Beginning (m/s)	Final Speed (m/s)	Change Speed (m/s)	Change Momentum (kg. m/s)
1.	....	....	....	....	....
2.	....	....	. ...	....	....
3.	....	....	....	....	....

Discussion

1. What is the relationship between the mass of the object and the change in the velocity of the object to the change in the momentum of the object based on the experiments that have been carried out?

Figure 15. Processing experimental data

questions posed in the discussion of the results. This phase also supports the pupils' generic science abilities, particularly their scale awareness.

According to Figure 16, during the stage of concluding the experiment, Students were asked to conclude the data, results, and discussion of the experiment that was carried out. This phase also enhances students' generic science skills, particularly regarding logical consistency.

Conclusion

Let's draw conclusions from the experiment. *Let's go!*

The clearer the conclusions you draw from the results of the data and discussion, the more your generic science skills in terms **of logical consistency will be.**

....
....
....
....

Figure 16. Draw the conclusion of the experiment

Stabilization Question 1

Take a look at both cases below!

- Case 1: Cars on the Highway

A car with a mass of 1.000 kg is moving at a speed of 10 m/s on the highway.

- Case 2: Wooden Boat Crossing a River

A wooden boat with a mass of 200 kg moves across a river at a speed 10 m/s.

Question:

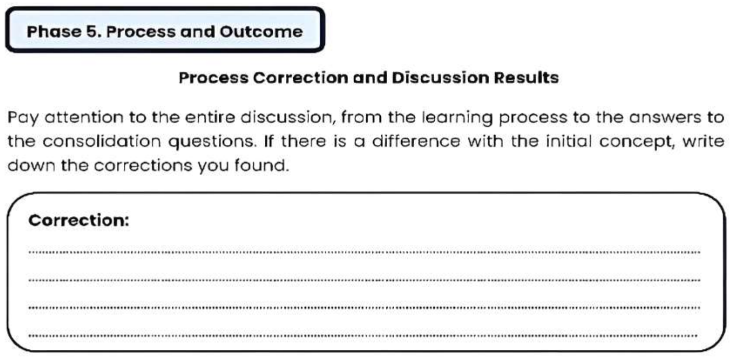
a. Calculate the momentum of the car aıd the wooden boat in both cases!
b. Explain how the magnitude of mass and velocity afteftect the magnitude difference in momentum of the two cases!

Settlement:

Figure 17. Working on consolidation issues

Based on Figure 17, students were also asked to solve the questions related to the learning material at the consolidation questions stage. This was done to consolidate the physics concepts with the learning material studied. The question of consolidation itself was contained in the module for each meeting.

Based on phase 5. In evaluating processes and results, educators assessed the outcomes of students' work in the generic module. They provided feedback to students, followed by students writing corrections in the module if there were differences with the initial concept.



Phase 5. Process and Outcome

Process Correction and Discussion Results

Pay attention to the entire discussion, from the learning process to the answers to the consolidation questions. If there is a difference with the initial concept, write down the corrections you found.

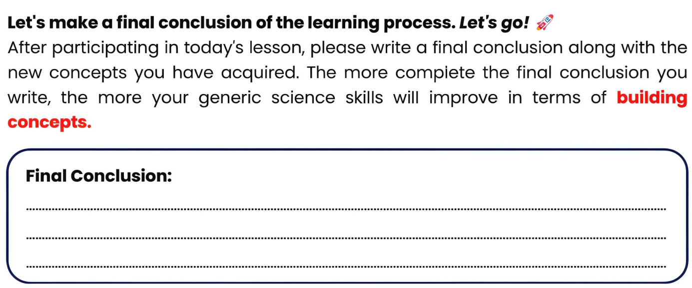
Correction:

Figure 18. Correcting the learning process

Furthermore, students were asked to conclude the learning process by documenting the concepts acquired from each session of the material studied. Additionally, this period helps students enhance their generic science skills, especially concept creation.

Effectiveness of Physics Modeling Learning Modules

Before and after using the physics modeling learning module, the students' generic science skills were evaluated using the pre-test and post-test results as a guide. The module's efficacy is assessed using the N-gain score. This assessment comprises nine questions that cover various aspects of general science skills. Modules are considered effective when the N-gain is minimal, specifically for science generic skills at 0.3.



Let's make a final conclusion of the learning process. *Let's go!*

After participating in today's lesson, please write a final conclusion along with the new concepts you have acquired. The more complete the final conclusion you write, the more your generic science skills will improve in terms of **building concepts.**

Final Conclusion:

Figure 19. Making a conclusion

Based on Table 2, the results of the effectiveness of the module were obtained with an average *pre-test* obtained by students of

Table 2. Findings from the module's effectiveness calculation

Pre-test average	Post-test average	N-gain	Category
25.25	85.87	0.81	High

25.25, which shows that the generic science skills of students are still relatively low, while the average *post-test* obtained of students is 85.87, which shows that the generic science skills of students have improved well. This is also supported by an N-gain score of 0.81 in the high category, indicating that the physics modeling learning module is effective for use in the learning process, particularly in enhancing students' generic science skills. This aligns with the view of Nurdini et al. (2021), who stated that students possess generic science skills if there is an improvement in test results before and after treatment (post-test).Students' general science skills (KGS) can be evaluated using the average scores of each KGS component employed in this study. Among the elements analyzed are the following: concept construction, scale awareness, logical consistency, logical framework, symbolic language, mathematical modeling, the rule of cause and effect, and direct and indirect observation. Below is a comparison of the mean scores for each pre-test and post-test component.

The pre-test results clearly showed that pupils' general scientific skills were deficient in every component of the KGS framework.

Table 3. Results of the KGS pre-test and post-test

Aspects of KGS	Average Pre-test		Post-test average	
	Value	Criterion	Value	Criterion
Direct observation	45.59	Quite skilled	92.65	Highly skilled
Indirect observation	46.32	Quite skilled	98.53	Highly skilled
Awareness of scale	35.29	Less skilled	80.88	Highly skilled
Symbolic language	30.88	Less skilled	94.85	Highly skilled
Logic framework	30.88	Less skilled	82.35	Highly skilled
Logical consistency	19.12	Unskilled	86.03	Highly skilled
Causal law	6.62	Unskilled	91.91	Highly skilled
Mathematical modeling	8.82	Unskilled	74.26	Skilled
Building a concept	2.21	Unskilled	72.06	Skilled

However, after implementing a treatment that used physics modeling learning to employ momentum and impulse modules, a significant improvement in post-test scores was observed in all KGS areas. This suggests that students learn significantly more and become more proficient in general science when they utilize the physics modeling learning module.

From what I saw personally, the students' average score on the post-test was 92.65, which is higher than their average score on the pre-test, which was 45.59. The indicators evaluated in this domain include the capacity to gather data from experiments and natural occurrences via the use of photographs (Herianto & Wilujeng, 2020). Also, there was a 47.06 difference between the kids' scores on the pre-test and the post-test. This shows that the students could perceive the tangible aspects of the photos through their senses. The pupils were also able to collect data from the results of the physical phenomena that occurred and then share their findings.

The students' average score on the post-test was 98.53, which was greater than their average score on the pre-test, which was 46.32. The pupils' scores on the post-test and the pre-test differed by 52.51 points. This demonstrates that students can utilize measurement tools as sensory aids to observe phenomena in the real world. Students may also learn something from the results of physical events. This further demonstrates how students' issues with the dearth of hands-on activities in the learning process can be resolved through the usage of physics modeling learning modules. Through hands-on activities, students actively participate in the learning process rather than just listening to what the teacher says. Students observe physical phenomena using their senses in these activities, gathering information from the experiments they conduct.

In terms of scale awareness, the students' average post-test score was 80.88, up from their average pre-test score of 35.29. Additionally, the students' pre-test and post-test results differed by 45.59 points. In addition to having a high sensitivity to numerical scales as a measure or unit of measurement on both microscopic and macroscopic scales, this indicates that children can now identify natural items.

The average score on the post-test for symbolic language was 94.85, representing a significant improvement from the average score on the pre-test, which was 30.88. There was also a 63.97 point difference between the students' results on the pre-test and the post-test. This implies that students can now apply arithmetic to solve physics problems or phenomena, understand the meaning of units and quantities in an equation, and recognize physics signs, symbols, and terminology. It also illustrates how employing physics modeling learning modules in the classroom can aid students who struggle with math formulas. In addition to applying physics formulae to solve problems, students also understand the meaning of the numbers in the units and quantities used in the equations required to do so.

The average score on the post-test for the logical framework was 82.35, which is greater than the average score on the pre-test, which was 30.88. The pupils' results on the pre-test and post-test differed by 51.47 points. This demonstrates that as the students worked on issues, they could perceive how two physics concepts were connected.

The students' average score on the logical consistency post-test was 86.03, which is greater than their average score on the pre-test, which was 19.12. Logical consistency is a general ability that students use to solve problems by applying scientific concepts they already know (Boelt et al., 2022). The difference between the students' results on the pre-test and the post-test was likewise 66.91 points. This demonstrates that the students understood the rules, applied them to solve problems, and used them to support their arguments. Students may also use these ideas to make predictions about how things work in the real world.

The average score on the post-test was 91.91, which is better than the average score on the pre-test, which was 6.62. The difference between the students' results on the pre-test and post-test was also 85.29 points. This demonstrates that the kids could figure out why things occurred in real life. Students may also explain how two or more variables in a physical phenomenon are interrelated. This component illustrates that understanding core concepts is essential for clarifying a thought within the setting of contextual phenomena (Siahaan, 2019).

The students' average score on the post-test for mathematical modeling was 74.26, which is better than their score of 8.82 on the pre-test. The average scores of the pupils on the post-test and pre-test also varied by 65.44. This illustrates that the pupils could use math and graphics to explain ideas or issues. Additionally, by providing solid answers to physics questions, students demonstrated several methods for addressing difficulties. This suggests that the challenges students face in comprehending physical phenomena may be alleviated by using physics modeling learning modules within the educational environment. Students may not only answer physics questions, but they can also use drawings or real-life examples to explain or depict how things work in the actual world.

The average score for generating ideas on the post-test was 71.06, which was higher than the average score on the pre-test, which was

2.21. The difference between the students' results on the pre-test and the post-test was also 69.85 points. This indicates that you can learn more about a physical phenomenon by using what you already know. This demonstrates that the use of physics modeling learning modules in the educational process may assist students who struggle with abstract concepts and numerous equations found in conventional teaching materials. Students may formulate concepts and further refine their ideas by applying the information they have studied to understand a physical occurrence or physics problem, rather than merely reproducing the teacher's words.

Kurniawan and Nawahdani's (2024) research supports this conclusion by demonstrating how extensive scientific skills might enhance students' study efficacy. Moreover, these findings corroborate the perspective of Utami et al. (2023), who assert that generic scientific skills facilitate the interplay between skills and newly produced or discovered ideas, principles, and theories, hence promoting active student engagement in the learning process. Furthermore, it has been demonstrated that incorporating interactive learning tools, such as PhET, into the curriculum enhances students' overall scientific skills. Sukmawati et al. (2021) assert that interactive media learning significantly improves students' conceptual understanding. Haryanto et al. (2024) also noted that PhET apps enhance the learning process by improving scientific abilities, enabling students to grasp concepts more effectively and organize practical activities more efficiently. Additionally, by giving feedback and a supportive environment, PhET applications encourage an interactive and constructivist approach by highlighting the relationship between real-life occurrences and fundamental scientific ideas. This supports the claim made by Diab et al. (2024) that PhET simulations help students gain a deeper conceptual understanding of various topics by providing dynamic and scientifically accurate representations of complex scientific concepts.

The average post-test score based on the information in Table 5 for the mathematical modeling and concept formation aspect was the lowest compared to the average post-test scores for the other elements, all of which were in the skilled category. Additionally, it was evident from the pre-test results that, except for the law of cause and effect, which was classified as unskilled, the average student score in the mathematical modeling and concept formation area was also the lowest compared to the average pre-test scores for the other aspects. This outcome aligns with research by Sakliressy et al. (2021), who noted that concepts related to collisions, the momentum-impulse relationship, and the conservation of momentum rule encompass a broader range of subjects. Consequently, students must dedicate more time to these topics than others, which can hinder their mastery of physics concepts. Furthermore, a study by Rehman et al. (2021) revealed that many students tend to memorize definitions and formulas related to physics concepts, which hinders their ability to connect these concepts to real-life situations and effectively solve complex problems.

The data in Table 5 indicate that students' generic science skills have improved most significantly in the areas of mathematical modeling and concept formulation, as well as the law of cause and effect. The significant difference between the mean scores on the mathematical modeling pre-test and post-test, as well as the concept creation components, serves to prove that the mathematical modeling aspect showed a score difference of 65.44. Meanwhile, the concept building aspect showed a value difference of 69.85. The improvement derived from the disparity between the average results before and after the exam indicates that, by the cause-and-effect rule, the physics modeling and concept formation aspects represent the most significant improvement in achieving generic science skills, even though their mean post-test scores were the lowest. The average scores received for both areas decreased because, at the time of the pre-test, students lacked sufficient prior knowledge to work on and solve physics problems that required generic science skills, such as aspects of mathematical modeling and developing concepts related to momentum and impulse topics. This is supported by research by Pamungkas & Wardani (2024), which shows that students still struggle to solve physics problems with a deep understanding of the material and the use of many equations. Additionally, Adianto & Rusli (2021) distinguished two types of difficulties students encounter while attempting to solve problems involving momentum and impulse. The first category relates to conceptual difficulties, which include students' difficulty understanding the problem and selecting the correct equation. The second kind is procedural issues, which come when pupils cannot complete the math they need to accomplish or enter the appropriate numbers into the equation.

The physics learning modules include real-life physical events, allowing students to recognize them more quickly and encouraging them to learn more about the physical symptoms. The research by Marcinauskas et al. (2024) demonstrates that students are more motivated when learning about real-life events. This supports this claim. This technique facilitates an understanding of fundamental ideas and principles of physics, rather than merely memorizing material. Moreover, the physical phenomena happening throughout the learning process are clarified by modeling techniques based on physics. The findings of Arifuddin et al. (2022) support this viewpoint, claiming that physics modeling promotes the cultivation of advantageous concepts and competencies by allowing students to conceptualize both practical and scholarly obstacles. This aligns with the findings of Kannadass et al. (2023), who suggest that classroom modeling enables students to think more flexibly, logically, and systematically, thereby improving their understanding of real-world math and physics problems.

Physics modeling was utilized to develop the Momentum and Impulse Module, which has proven beneficial in the educational process, particularly in enhancing students' overall scientific competencies, as indicated by the N-gain scores. This result supports the view of Ardiningtyas et al. (2024), who argue that a module is effective if students complete it and the learning experiences and outcomes are meaningful. A paired t-test was used to assess the significance of the data before and after the therapy. It was also used to determine the N-gain scores for the research data, ensuring the findings were statistically sound. Prior to the paired t-test, the *SPSS* software and the Kolmogorov-Smirnov method were used to assess normality (Habibzadeh, 2024). The paired t-test is valid after validating the normal distribution of the data (Fiandini et al., 2024). This test aims to determine if the findings before and after the therapy show significant differences (Coban et al., 2025).

The *SPSS* software checked the data for normality and determined that it had a normal distribution, with a significant value (Sig.) of 0.200, which is greater than the threshold of 0.05. The *SPSS* software also used a paired sample t-test on the data from the pre-test and post-test. The test results are displayed in the table below.

Table 4. Results of the paired sample t-test

Paired Samples Test							
Paired Differences					t	Df	Sig.(2-tailed)
Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
			Lower	Upper			
-60.60971	13.16558	2.25788	-65.20339	-56.01602	-26.844	33	0.000

The results in Table 4 indicate that the paired sample t-test gave a t-value of -26.844 and a significance value (Sig.) of 0.000, which is below the alpha level of 0.05 (0.000 < 0.05). The results show that the alternative hypothesis (Ha) is true and the null hypothesis (Ho) is false. The substantial difference in mean scores between the pre-test and post-test demonstrates the degree to which physics modeling learning modules centered on momentum and impulse concepts enhance students' overall scientific abilities. The claim (Afifah et al., 2022) that positive changes before and after learning may improve student learning outcomes further supports this conclusion. Saragih et al. (2021) contend that students who achieve positive learning outcomes have successfully met their educational objectives.

CONCLUSION

This study aimed to evaluate the impact of physics modeling learning modules on students' overall scientific performance, specifically in the areas of momentum and impulse. The study's results demonstrate that physics modeling (P2F) learning is an effective method for enhancing students' overall scientific abilities, particularly in the areas of momentum and impulse. We utilized a measure of student learning outcomes to assess the effectiveness of this learning. The test had a high intercept and an average n-gain KGS score of 0.81. This suggests that incorporating the physics modeling learning module into the curriculum was beneficial, particularly in enhancing students' overall understanding of science. Students also demonstrated proficiency in other domains, including the law of cause and effect, the logistic framework, logistic consistency, awareness scale, symbolic language, and direct and indirect observation, among others. They also performed very well in areas related to mathematical modeling and generating new ideas. According to statistical analysis, the pre- and post-treatment scores differed significantly, as indicated by paired sample t-tests. This suggests that after the educational intervention, the application of the physics learning module significantly enhanced generic science abilities.

This study presents new findings from previous studies, including the application of physics modeling learning models through the use of learning modules on momentum and impulse materials to enhance students' generic science skills. The teaching materials used are not conventional, but rather modules that incorporate physics modeling learning syntax, encouraging students to enhance their general science skills. The findings of this study also indicate that the use of physics modeling learning modules can serve as an alternative strategy to enhance students' generic science skills. Additionally, physics modeling learning modules can be used to explain abstract and difficult-to-visualize concepts directly through physics modeling.

In light of the findings of the study, the researcher offers recommendations for other researchers in the future if they want to conduct similar research to develop a physics modeling learning module by paying attention to and emphasizing aspects and indicators of generic science skills in making test questions to be measured to be more effective in measuring students' generic science skills. Additionally, note the amount of time spent on the learning process. This is because the use of learning models, such as physics modeling learning, in schools is still relatively new, and it takes longer to adapt the model to meet the intended learning goals effectively between students and teachers.

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