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The Effectiveness of Multimodel in Physics Learning to Train Students' Problem-Solving Skills

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Abstract

The low ability of students to solve problems is caused by a lack of understanding of concepts and their inability to apply solutions to the problems given. In this regard, this study was conducted to overcome existing problems by applying multimodel learning. The subjects involved in this quantitative study had a pre-experimental design, namely 28 students of class XI A at one of the State Senior High Schools in Banjarmasin City. The data collection instrument was a learning outcome test that measured problem-solving abilities before and after the learning process. The study results showed increased learning outcomes, especially in students' problem-solving abilities, with an increased score of 52.4, which was classified as the medium category. Based on these results, the multimodel learning can successfully engage students in physics learning by enhancing their problem-solving skills.

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INTRODUCTION

The challenges of the 21st century are characterized by the acceleration of the development of science, technology, and information, as well as the absence of clear boundaries between "space and time" between countries (Fautin et al., 2021; Pawlak et al., 2020; Putri et al., 2023). Life in the 21st century demands mastery of various skills that need to be possessed, and the world of education is expected to be able to prepare students to master these various skills so that they can become successful individuals in life (Wati et al., 2021). 21st century skills have become a major focus in global education transformation in response to dynamic changes in the economy, technology, and culture (Arsyad et al., 2020; Qotrunnada et al., 2023; Wati et al., 2024).

The current educational process is not only required to transfer academic knowledge simply, but more than that, the educational process must be able to develop critical, creative, communicative, and collaborative thinking skills in students (Azmi & Festiyed, 2023; Firmansyah et al., 2022; Triana et al., 2019)These skills are crucial in the modern world of work. The integration of digital technology and a focus on interpersonal skills are also vital in preparing the next generation to face increasingly complex and interconnected global challenges.

One of the main skills students must master in the 21st century is problem-solving skills. Problem solving skills include the ability to search, identify, select, evaluate, organize, consider various alternatives, and interpret information (Chiu et al., 2022; Felmer, 2023; Han et al., 2023; Molnár & Greiff, 2023; Salam et al., 2017; Urban & Urban, 2023). In solving problems, individuals are required to be able to find various alternative solutions by utilizing diverse perspectives. Problem-solving skills are identifying problems, analyzing information, and finding the right solution (Çalkan et al., 2010; Sitti et al., 2013; Sum & Bădescu, 2023; Sun et al., 2020). In 21st-century learning, students are trained to develop problem-solving skills through critical and creative thinking skills and effective collaboration and communication. By developing problem-solving skills, students are expected to be better able to face life's challenges in the 21st century.

Several studies have tried to identify various factors that cause low problem-solving skills in Indonesia. One of the main causes is the inability of students to design and implement effective problem-solving techniques (Sanjayanti & Pramadi, 2020; Trisnawati & Sari, 2019)Another contributing factor is the lack of student motivation and enthusiasm for learning, which is often compounded by limited interaction and guidance from teachers, as observed in a school in Banjarmasin.

While previous research has discussed these challenges, there remains a notable gap in the empirical application of multimodel-based learning to enhance problem-solving skills in physics education. Most existing studies either focus on a single instructional model or address problem-solving in general without exploring how an integrated, multimodel approach can target students' cognitive development in a physics context. In other words, this study's unique contribution lies in its focus on how multimodal learning can concretely improve analytical and procedural problem-solving abilities in the classroom.

The novelty of this study is not just in promoting multimodel learning, but in how it strategically combines various learning models into a cohesive framework that supports the development of students' critical, creative, and analytical thinking, specifically in physics problem-solving. This integrated approach is expected to offer a more effective alternative than conventional single-method teaching strategies, thus providing new insights into instructional innovation in science education. Improving problem-solving abilities in students is very important, as it focuses on the learning paradigm used in the classroom and developing learning resources. Multi-model learning is a strategy that integrates several learning models to achieve certain learning objectives (Putri et al., 2023). To train students' problem-solving skills in the modern era, applying multimodel learning models can facilitate the development of critical, creative, and analytical thinking skills.

It is also very important to focus on the learning paradigm used in the classroom, in addition to developing learning resources. Multi-model learning is a strategy that integrates several learning models to achieve certain learning objectives (Putri et al., 2023)The application of multimodel learning models can facilitate the development of critical, creative, and analytical thinking skills, which are essential for training students' problem-solving skills in the modern era.

The effectiveness of multi-model learning in improving learning outcomes, including problem-solving skills, has been proven through many studies, the results of the study showing the effectiveness of using multi-models (direct teaching and cooperative learning) in improving problem-solving skills in physics learning (Agustina et al., 2022; Fautin et al., 2021; Lailis et al., 2021; Miriam et al., 2023; Nida et al., 2021; Putri et al., 2023). The results of the study show that there has been an increase in the problem-solving abilities of students. The implementation of multi-model learning, consisting of direct teaching, cooperative learning, and inquiry learning, is applied to Physics of straight motion. The same results were obtained previously (Yanti et al., 2023) which reveals that multimodel learning, direct teaching, and cooperative learning can improve students' learning outcomes on Dynamic Fluids. The increase in learning outcomes was obtained with a gain score of 0.69 (medium category).

Educators must determine appropriate learning methods, strategies, or models to improve students' problem-solving abilities. With multimodel learning, teachers can guide and assist students optimally in overcoming challenges in learning physics. This will lead to increased effectiveness, efficiency, and attractiveness of the learning system implemented by teachers.

METHODS

This study is categorized as quantitative research that adopts a pre-experimental design. This study does not include a control class and only involves the experimental class. Treatment was given to twenty-eight eleventh-grade students in a public school in North Banjarmasin. The module used in this study is a teaching module containing the character of the Pancasila student profile to train problem-solving skills, declared valid based on the results of academic and practitioner assessments of the teaching module. The format aspect of the module gets a very good category (score: 3.61), this is because the Teaching Module Format has meet the criteria, namely the format/components of the Kurikulum Merdeka Teaching Module; is in accordance with the independent curriculum with a clear numbering system, appropriate font type and size, balanced text and illustration images and regularity between components and sub-components. The language aspect obtained results in the good category (score: 3.16) and it can be concluded that the language in the teacher's teaching module is in accordance with Indonesian language rules, consistency in the use of symbols/emblems, the suitability of illustrations with the substance of the message to be conveyed with the material and there is no double meaning. The content aspect of the teacher's teaching module obtained results in the good category(score: 3.11), and it can be concluded that the contents of the developed teaching module have been arranged in accordance with the independent curriculum. The results of the content aspect of the teacher's teaching module (conceptual accuracy in the material to be conveyed) can be said to be appropriate, the accuracy of scientific nomenclature, terms, unit symbols are appropriate and the contents of the teacher's teaching module contain links to critical thinking skills in everyday life. The content of this teaching module also aims to train knowledge, where this teaching module focuses on the cognitive aspect.

The effectiveness aspect is an important criterion in every learning that is carried out, namely by achieving the learning objectives given. Learning effectiveness is measured using the Learning Outcome Test by calculating the N-gain value or normalized gain score. The calculation results are compared with the N-gain criterion (Hake, 1998). The indicators of problem solving in this study are describing the problem, describing physics, planning a solution, implementing the solution, and checking and evaluating.

RESULT AND DISCUSSION

Learning using multimodels applied to Motion Dynamics integrates two learning models: cooperative learning and direct learning. The first learning meeting is designed with a cooperative learning model. The subtopics discussed are Newton's Laws and the forces that can cause objects to change position or experience motion. This cooperative learning was chosen because this sub-topic is a repetition and reinforcement of the Physics material that students learned in junior high school. Students already have initial knowledge about the subtopics discussed, so teachers can optimize group discussions followed by classical discussions to refresh students' knowledge and understanding. This cooperative learning can also train social skills, including the ability to cooperate between students who are members of heterogeneous groups (Arends, 2015; Conney et al., 2016; Sandi-Urena et al., 2012; Sari et al., 2020).

The second meeting discussed the subtopic of solving problems of the dynamics of object motion on a flat surface, with or without friction. Students were directed to be able to develop problem-solving skills by utilizing their knowledge and understanding from the subtopic of the first meeting. To make it easier for students to solve academic problems, a structured problem-solving method was introduced using the method introduced by Heller (Heller et al., 1992).

The researcher used a direct learning model to introduce this problem-solving method by Heller. This model was chosen considering its effectiveness in teaching declarative knowledge and training students' procedural skills (Arends, 2015). According to Heller, after trying to raise motivation to learn, followed by the delivery of learning objectives, students are given a step-by-step explanation of the solution method. Furthermore, guided practice is carried out using the intended method to solve physics problems on the discussed topic. The next step of direct teaching is providing feedback and the opportunity to ask questions about things students do not understand. In the final syntax, students are allowed to carry out further training. If the discussion of the second meeting was about the motion of objects on a flat plane, then the third meeting of this study discussed the sub-topic of solving the problem of the dynamics of the motion of objects on an inclined plane, with or without friction. In this face-to-face meeting, direct teaching is still the researcher's choice, considering this topic is relatively new to students and involves slightly more complex mathematical procedural skills than before. In this activity, the teacher also provides relevant examples and provides a good opportunity for students to practice solving problems(Hanisa, 2018; Izzati et al., 2020; Noor et al., 2017; Ramadhanti et al., 2020; Thersia et al., 2019).

To assess how effective the implementation of the multimodel learning model is in training students' problem-solving skills, the reference for student learning outcomes is used. The essay-based Learning Outcome Test is given to students before and after they take part in learning with multimodels. The effectiveness of multimodel learning on the content (topic) of Linear Motion Dynamics is evaluated using the gain score, which is calculated from the results of the tests given at the beginning (pretest) and post-test).

Table 1 shows student learning outcomes in terms of problem-solving skills. The Learning Outcome Test contains three descriptive questions assessing students' abilities.

Table 1 Measurement of learning effectiveness

Score	**Pre-test**	**Post-test**
Highest Score	28	72
Lowest Score	0	36
Average Score	8.5	52.4
Gain score (category)	0.48 (medium)	

The developed learning device's effectiveness was evaluated by comparing student learning outcomes in the initial and final tests. Based on Table 1, before implementing multi-model learning, the average student learning outcome was recorded at 8.2, with the highest score reaching 28 out of a maximum of 100, and the lowest score of 0 out of a minimum of 0. After implementing multi-model learning, the average learning outcome increased to 52.4, with the highest student score increasing to 72 out of a maximum of 100, and the lowest score decreasing to 36 out of a minimum of 0. After learning, the average student learning outcome exceeded the N-gain threshold, indicating a fairly high level of effectiveness. The increase in student test results indicates that the applied learning model has increased students' cognitive capacity during learning practice.

Based on the analysis of the average pre-test score, there was a significant increase in the average post-test score. This increase is supported by the results of the N-gain test, which shows that the N-gain score is in the medium category. This indicates that multimodel learning has proven effective in improving student learning outcomes, especially regarding problem-solving skills. The results of this study also strengthen the findings of previous studies regarding the effectiveness of multimodel learning in improving student learning outcomes (Lailis et al., 2021; Nida, et al., 2021)and not only limited to problem-solving skills. The success of this multimodel learning can be seen from the results of relevant research, which shows that multimodel learning can improve students' problem-solving skills (Agustina et al., 2022; Fautin et al., 2021; Putri et al., 2023; Yanti et al., 2023).

The changes in pretest and posttest scores indicate that students' learning outcomes have increased. However, when viewed based on the minimum completion criteria set at the school, the post-test results of these students are not yet satisfactory because some students have not met the minimum completion criteria. Thus, teachers still need continuous efforts so that, in the end, all students can meet the minimum completion criteria in question. Table 2 shows how to improve the score on each indicator of problem-solving skills.

Table 2 Results of the average value of problem-solving skills per indicator

Indicators	Pre Test	Post Test
Describing the Problem	35.02	70.38
Describing Physics	16.02	44.05
Planning Solutions	3.09	55.02
Implementing Solutions	0	54.49
Checking and Evaluation	0	48.27

The improvement in each stage of the problem-solving ability indicator cannot be separated from the example questions and questions arranged systematically according to the stages of problem-solving ability. And with the design of the learning model at the first meeting with the cooperative learning model that focuses on the basic understanding of students so that students find it easier to follow the more complex learning stages at the next meeting with the direct learning model that focuses on teachers specifically to develop student learning about procedural and declarative knowledge that is well structured and can be taught step by step to students who match the stages of problem-solving ability.

Then, from the table, we can see a significant increase in the average per indicator of students' problem-solving ability, where in the first indicator, there was an increase in ability of 35%, where students were better able to describe and determine related symbols in the picture. In the second stage, there was an increase of 28% from the pre-test results. However, from this increase, the students' scores were still relatively low because many students were still unable to correctly determine the direction of the forces that had to be described in the picture. In the third stage, there was an increase in ability of 52%, from which the average score of students was already in the sufficient category. In the fourth stage, there was an increase of 54% from the previous stage, where students could not implement the solution at all. This was also because in the previous stage students had not been able to plan the solution correctly; likewise in the fifth stage there was an increase of 48% from the previous students who were unable to check and evaluate at all because in the previous stage the solution and plan that were determined could not be determined correctly.

The above shows that the developed device successfully trains students' problem-solving skills from pre-test to post-test scores. This means that students' ability to solve problems is better than before being given treatment, starting from visualizing the problem (describing the problem in the question), describing the problem (describing a problem sketch, identifying known quantities, identifying quantities in question), making a problem-solving plan (determining the right equation to solve the problem), implementing the problem-solving plan (performing calculations using the selected equation), and rechecking (reviewing and rechecking the results obtained) correctly.

The problem-solving ability of students, when viewed from the stage of describing the problem, is still in the very low category. This is because it is still new to them at this stage, so most students skip this stage and prefer to continue to the next stage for efficiency of work time. Most students who answer this stage are still wrong in describing the problems in the questions, such as haphazard depictions, and drawing problems without providing any components that should be in this stage. At other stages, such as implementing problem plans as in questions 2 and 3, they are still low because many of the students previously wrote the equations in the problem planning stage incorrectly, so the results obtained are low when they work on this stage. In general, the ability of students has increased before being taught using a direct teaching model, where this direct teaching model is the result of thinking from Albert Bandura's learning theory, which states that learning is a process of imitation or modeling. Students will observe and pay attention to the behavior of others who are considered models, in this case, namely teachers, when teachers teach something to students, when students get something useful for themselves, or get a good response from the model observed, then they tend to imitate that behavior. The concept of internal mediation plays an important role in the internal mental process in learning and behavior; for example, when students are observing the ongoing learning process they will process information through their observations and consider whether this information is acceptable, examine the possibilities that occur, and decide whether to imitate and accept the behavior they are observing. It can be concluded that students who are taught with a modeling system will get a better experience than students who are taught without using modeling, because this is in accordance with Bandura's learning theory, where students tend to observe what is modeled by the teacher.

CONCLUSION

Based on the results and discussions that have been carried out, it can be concluded that multi-model learning effectively improves students' problem-solving abilities, with an increase score of 0.48, which is included in the medium category. Based on these results, multi-model learning can successfully engage students in physics learning by enhancing their problem-solving skills. Thus, multi-model learning can be an alternative choice for Physics teachers/instructors to implement in learning so that it can improve students' Physics learning outcomes, even for other subjects.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS STATEMENT

All authors have contributed to the conceptualization, methodology, formal analysis, investigation, and writing this article.

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