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Teaching Materials for Dynamic Fluids: An Application of Multimodels to Teach Learners' Problem-solving Ability

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Abstract

Students' ability to solve physics problems is still relatively low, which triggers research to apply various learning models to the learning process. This research aims to test the effectiveness of multimodels in dynamic fluid material to train students' problem-solving abilities. This research used a quantitative research method, which is a Pre-experiment Design. The research trial subjects were 27 students in class XI MIPA 3 SMA Negeri 10 Banjarmasin. Data collection techniques were seen from measuring multimodel learning outcomes based on pre-test and post-test results. Meanwhile, data analysis techniques were taken descriptively, quantitatively, and qualitatively. Based on research results, multimodel learning has a medium level of effectiveness, so it can be implemented in the learning process. Therefore, this multimodel learning can be used as an alternative for training students' problem-solving abilities.

Keywords: Dynamic Fluid; Problem-Solving Ability; Multimodels

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INTRODUCTION

Technology progress is significantly influenced by physics. Both a process and an outcome are associated with the discipline of physics. Therefore, effective and efficient strategies and methods must be considered during the learning process. Furthermore, the study of physics cultivates problem-solving abilities, teaches how to acquire information, and applies technology in daily life (Chiu et al., 2022; Suryaningtyas et al., 2020).

In 21st-century education, problem-solving ability is required. The problem-solving process involves the ability of individual thinking to obtain solutions and overcome a problem by utilizing various sources of information. In addition, the ability to draw conclusions based on the problem is also part of the process (Widiyanto et al., 2021; Widodo, 2017).

Hence, teachers are anticipated to possess the capacity to develop pedagogical approaches and methodologies that facilitate an effortless

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cycle of learning (Burkholder et al., 2020). Therefore, to develop students' problem-solving abilities in physics, an instructional strategy that promotes student engagement and facilitates the resolution of issues about physics concepts is required. In addition to providing students with physics-related problem-solving activities and strategies, teachers must possess the knowledge and abilities necessary to develop effective teaching methods and strategies that ensure student success.

Multi-model learning is widely regarded as an efficacious approach due to its exhaustive consideration of both the attributes of instructional materials and the characteristics of learners (Ozsoy & Ataman, 2009). Integrating various learning models into its implementation generates a comprehensive and exhaustive educational encounter. Multi-model learning is regarded as an efficacious approach due to its careful consideration of both the attributes of instructional resources and the characteristics of students (Maria, 2010; Nida, Salam, et al., 2021). Implementing multimodel learning is anticipated to empower students to enhance their comprehension and complete the established base competencies.

The main problem in contemporary physics education is students' inadequate assimilation and learning outcomes. Research findings further support this conclusion (Fitriana & Supahar, 2019; Haris et al., 2021), indicating that secondary school students encounter challenges when attempting to solve physics problems.

The researchers initiated the investigation by interviewing the physics teacher at SMA Negeri 10 Banjarmasin. The curriculum that was implemented was determined to be the 2013 revised curriculum. Teachers employ conventional methods that lean towards the teacher-centered perspective when imparting knowledge, including lectures, discussions, and practice questions. As a result, students often exhibit passivity when confronted with challenges in problem-solving. Even though classroom learning has evolved to meet the needs of the 21st century, some students continue to encounter learning difficulties.

The outcomes of the preliminary observation test conducted on August 24, 2022, at SMA Negeri 10 Banjarmasin further substantiate this assertion. Twenty-seven students in class XI MIPA 3 were handed this examination, which assessed their ability to solve physics problems with real-world applications. The findings indicated that the KPM of physics students in class XI MIPA 3 remained significantly inadequate. Teachers can master the subject matter, design learning, and establish an engaging and interactive learning environment using creative and innovative learning models (Tiur Maria, 2012). The objective is for students to attain knowledge and comprehend the subject matter in order to fulfill the learning goals. Furthermore, teachers must be informed of students' challenges while attempting to learn (Afandi et al., 2019). Consequently, this element impacts the researchers' determination to employ multimodel learning on dynamic fluid content to instruct students in problem-solving abilities.

Multi-model learning refers to implementing multiple learning models to enhance learning outcomes. Students are encouraged to assume an active and autonomous role, beginning with the teacher in their entirety (Lailis et al., 2021). The effectiveness of incorporating multi-model-based physics learning into the learning process has been established by pertinent research (Fautin et al., 2021; Nida et al., 2021; Putri et al., 2023). The present study integrates three distinct learning models: 1) project-based learning; 2) cooperative learning; and 3) direct teaching.

The syntax of the direct teaching model comprises five phases of instruction: Phase 1 consists of communicating objectives and preparing students; Phase 2 involves assessing knowledge and procedural proficiency; Phase 3 involves facilitating guided instruction; Phase 4 involves evaluating comprehension and offering feedback; and phase 5 concludes with the provision of additional training and transfer (R. Arends, 2015). Phase 1 involves motivating students and communicating objectives; Phase 2 involves disseminating information; Phase 3 involves coordinating learning groups; Phase 4 involves facilitating group discussions; Phase 5 involves evaluating; and Phase 6 involves awarding. The project-based learning model comprises six phases, as delineated in its syntax: Phase 1 encompasses the identification of the primary inquiry; Phase 2 pertains to the formulation of the project plan; Phase 3 concerns the preparation of the project; Phase 4 entails the oversight of project progress and development; phase 5 concerns the testing of outcomes; and phase 6 pertains to the evaluation of the learning experience (Amalia et al., 2019; Bender, 2012; Lou et al., 2017).

One of the benefits of this learning environment is that it is multimodel, meaning that various learning models are utilized during each learning session by the characteristics of the teaching materials and students. Multimodel learning additionally emphasizes the application of the problem-solving ability with students through the utilization of the Heller method (Heller et al., 1992b). The distinction between the present study and previous studies resides in the instructional materials and learning models implemented during each session.

Initial analysis and observations indicate that several factors, including the subject matter, classroom teaching and learning activities, and the teaching manner of the instructor, influence the issue. In order to address this difficulty, a dynamic fluid material-based multimodel-based learning approach is implemented to instruct students' problem-solving ability and foster a proactive environment of motivating and innovative learning. This research aims to examine the efficacy of multimodels on dynamic fluid material to develop students' problem-solving abilities.

METHOD

This study was designated as quantitative research and employed a one-group pretest-posttest design, in which the experimental class exclusively served as the research subject and the control class was excluded. To determine whether or not the treatment enhanced learning. The design of the investigation is illustrated in Table 1.

Table 1 Product trial design

Pre-test	Dependent Variable	Post-test
O_1	X	O_2

Information:

X = learning using multimodel teaching material (treatment, independent variable)

O_1 = test before learning using multimodel teaching material (dependent variable)

O_2 = test after learning using multimodel teaching material

Multimodel learning was tested on 27 students at SMA Negeri 10 Banjarmasin, class XI MIPA 3. This research was conducted from September to December 2022. The research design used a one-group pretest-posttest design, where the treatment in the form of multimodel learning was applied to students in class XI MIPA 3. Effectiveness was reviewed by measuring the achievement of multimodel learning using problem-solving tests in the form of pre-test and post-test results. To analyze learning outcomes, the N-Gain value, or normalized gain score, is calculated using the following equation:

$$\langle g \rangle = \frac{(\%\langle S_f \rangle - \%\langle S_i \rangle}{(100 - \%\langle S_i \rangle)} \quad \ldots(1)$$

The calculation results are compared with the N-gain criteria in Table 2.

Table 2 Criteria *N-gain*

Value $\langle g \rangle$	Category
$\langle g \rangle \geq 0{,}7$	High
$0{,}7 > \langle g \rangle \geq 0{,}3$	Medium
$\langle g \rangle < 0{,}3$	Low

(Hake, 1998)

Problem-solving ability scores are adjusted to the assessment criteria as in Table 3.

Table 3 Criteria for problem-solving ability

Score Interval	Category
$P_i > 80$	Very good
$60 < P_i \leq 80$	Good
$40 < P_i \leq 60$	Less Good
$20 < P_i \leq 40$	Not good
$P_i \leq 20$	Not very good

(Widoyoko, 2017)

RESULT AND DISCUSSION

This research aims to assess the efficacy of multimodel learning in enhancing human comprehension of dynamic fluid materials. Collecting data on learning outcomes by cognitive problem-solving assessments with pre-tests and post-tests administered to students provides insight into the efficacy of the learning process (Ariyanti et al., 2022; Devanti et al., 2020; Royantoro et al., 2018). Effective learning is characterized by the students' generation of favorable learning outcomes (Azhary et al., 2022). The developed assessment for learning outcomes consists of four essay queries pertinent to the stated learning objectives. Table 4 presents the outcomes of the students' N-gain computation.

Table 4 N-gain Results

Average		*N-gain*	Category
Pre-test	***Post-test***		
10.39	71.81	0.69	Medium

The achievement of students' problem-solving abilities was measured using pre-test and post-test questions, which were reviewed based on the average score at each problem-solving stage. A comparison of the average scores is shown in Figure 1.

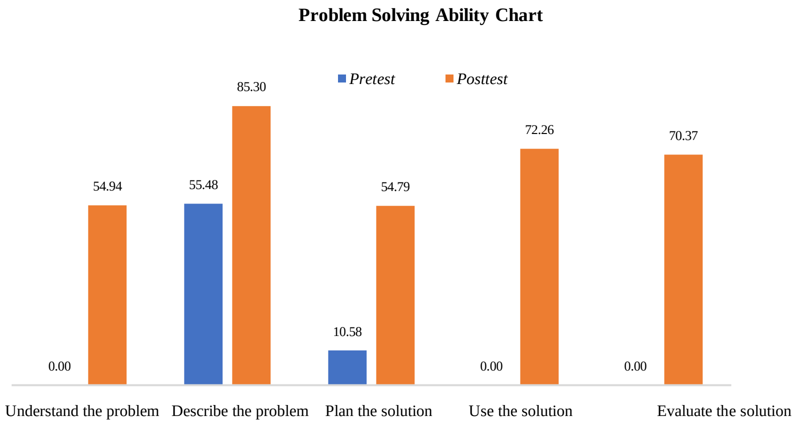

Figure 1 Comparison of average scores between pre-test and post-test

Figure 1 shows a comparison of the results between the pre-test and post-test of students at the problem-solving stage. From the figure, it can be seen that there was a significant increase in the post-test scores of all students after implementing multimodel learning.

The significant increase is due to the role of multimodel learning, and at each meeting, students are trained in groups to solve physics problems with the stages of problem-solving. Discussion allows each learner to develop rational problem-solving skills, which have been proven to improve the quality of learner learning (Avry et al., 2020; Han et al., 2023). The essay questions trained for problem-solving ability involve the C3 and C4 cognitive domains. Each problem follows the stages of the problem according to its ability; the goal is to develop students' ability to solve problems in a structured manner and improve students' problem-solving ability (Agustina et al., 2022; Fahrina et al., 2018).

Despite this, several students failed to meet the Minimum Completeness Criteria, as indicated by their post-test scores. This is the result of students' imprecise problem descriptions and calculation execution. The post-test questions were reviewed and rehearsed throughout the learning process. Despite this, the stages of problem-solving produce satisfactory outcomes on the whole. This result is supported by the findings of Mahrita et al. (2023), who concluded that students will respond positively to solving problems utilizing the problem-solving stage, leading to improved learning outcomes.

N-gain analysis aims to determine whether or not student achievement of learning outcomes has increased. (Hake, 1998a, 1998b) The N-gain results obtained in this study classify the degree of learning effectiveness as either effective or moderate. This is because employing multimodels on dynamic fluid material featuring ideal fluid sub-points and the principle of continuity, which was introduced in the initial meeting via a direct teaching model, contributed to the learning process. Concurrently, the second meeting was conducted using a direct instructional approach, focusing on the subsidiary subject matter of Bernoulli's law. The expansion of declarative and procedural knowledge is facilitated by the direct teaching method (Fitriah, 2019; Izzati et al., 2020; Rizki et al., 2022; Yudani et al., 2018). In addition, the third and fourth meetings discussed the application of Bernoulli's law.

The third meeting uses a cooperative learning model that provides opportunities to learn in groups by respecting each other's opinions and providing space for each individual to contribute (Heller et al., 1992a; Navisah et al., 2021; Slavin, 2015; Yatimah et al., 2019). The fourth meeting used a project-based learning model to improve students' problem-solving abilities (Putri & Dwikoranto, 2022). The product made is a wheel that utilizes Bernaulli's law, as shown in Figure 2.

Figure 2 A simple project applying Bernaulli's law

The results of this study align with previous research (Agustina et al., 2022), which assessed the effectiveness of problem-solving abilities instruction using multimodel learning. Moreover, this relates to the qualities of state-of-the-art educational materials, where that which is taught can be improved through multimodel learning.

CONCLUSION

Teaching students' problem-solving abilities with multimodel learning on dynamic fluid material has been effective. Moderate N-gain was determined to be 0.69, according to the results of the experimental investigation. Consequently, multimodel learning might be incorporated into the learning process as an efficacious approach to enhancing students' problem-solving abilities. Regarding the enhancement of students' problem-solving abilities, it is expected that the findings of this study will provide data that can serve as a basis for consideration, support, and contribution to the field of education.

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