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Analysis of Scientific Literacy and Need to Develop POE-Based Student Worksheet in Dynamic Material for High School

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ABSTRACT

This research is motivated by the importance of scientific literacy in physics learning, particularly in dynamics material, which requires students to understand concepts, interpret data, and explain scientific phenomena logically. However, students' scientific literacy skills are still not optimally developed, especially in higher-order competencies such as scientific investigation and data interpretation. This study aims to analyze students' scientific literacy levels and identify the need for the development of Predict–Observe–Explain (POE)-based student worksheets in dynamics learning. This study employed a descriptive method with both quantitative and qualitative approaches. The subjects were 30 students of grade XI Phase F2 at a Madrasah Aliyah in Pariaman City. Data were collected through scientific literacy tests, student questionnaires, document analysis, and interviews with physics teachers. The results showed that students' scientific literacy achievement was 58.66% in explaining scientific phenomena, 46.67% in evaluating and designing scientific investigations, and 46.66% in interpreting scientific data and evidence. These findings indicate that students' scientific literacy is still in the moderate category and needs improvement. Therefore, the development of POE-based student worksheets is necessary to facilitate prediction, observation, and explanation activities to enhance students' scientific literacy in dynamics learning.

INTRODUCTION

Physics learning plays a crucial role in developing students' scientific thinking skills, as it encompasses not only concepts, principles, and laws of nature but also requires the ability to apply this knowledge to explain phenomena, interpret data, and make decisions based on empirical evidence. Physics learning is also closely related to the development of students' scientific literacy and higher-order thinking skills (Handayani et al. 2022; Kurniawati et al., 2021). Scientific literacy has become an essential competency in 21st-century education. According to OECD (2023), scientific literacy is defined as an individual's ability to engage with science-related issues as a reflective citizen, including the ability to explain phenomena scientifically, evaluate and design scientific investigations, and interpret scientific data and evidence. This implies that physics learning should not merely focus on mastering formulas, but also on developing students' ability to connect concepts with real-world phenomena. However, in practice, students often experience difficulties in explaining scientific phenomena, interpreting data, and applying concepts in real-life contexts. Several studies also indicate that students' scientific literacy in physics learning is still relatively low (Hidayat et al., 2022; Sari et al., 2022). This condition indicates the need for learning innovations that can facilitate the development of students' scientific literacy.

One learning model that can be used to address this issue is the Predict–Observe–Explain (POE) model. This model encourages students to actively construct their understanding through predicting, observing, and explaining phenomena. Several studies have demonstrated the potential of the POE model in improving the quality of science learning. Tüysüz and Demir (2023) reported that the POE model positively influences students' conceptual understanding, while Pektaş and Özdemir (2024) found that simulation-supported POE strategies effectively enhance students' critical thinking skills. Furthermore, the development of POE-based student worksheets has been shown to promote student engagement and support higher-order thinking skills (Elviana et.al., 2024). Therefore, strengthening scientific literacy is an important goal in physics learning, especially in topics such as dynamics, which require strong connections between concepts, phenomena, and evidence-based reasoning. Based on this, it is necessary to develop learning materials that can support students' scientific literacy, one of which is through POE-based student worksheets on Newton's laws of motion.

The urgency of strengthening scientific literacy is increasingly evident when linked to the achievement of Indonesian students in international assessments. In PISA 2022, Indonesia's average science score was 383, which is below the OECD average of 485 (OECD, 2023). These results indicate that students' ability to use scientific knowledge to understand contextual issues, evaluate information, and interpret scientific evidence still needs improvement. This condition is supported by various studies showing that students' scientific literacy in physics learning has not developed optimally (Hidayat et.al., 2022; Sari et.al., 2022). Meta-analysis studies also indicate that learning models influence students' scientific literacy, highlighting the importance of the quality of learning experiences (Apriyani et.al., 2021). Furthermore, students still experience difficulties in scientific reasoning, data interpretation, and applying concepts in everyday life contexts (Pratiwi et.al., 2021). Thus, the issue of low scientific literacy is closely related to learning characteristics that have not fully provided opportunities for students to engage in scientific activities.

In physics instructional practices at school, the learning process is still dominated by teacher explanations, the use of informative teaching materials, and practice problems oriented toward final answers. This learning pattern tends to cause students to passively accept concepts, while opportunities to observe phenomena, test hypotheses, interpret data, and construct scientific explanations are still limited. However, in dynamics, students are not only required to understand the relationship between force, mass, and acceleration, but also to be able to explain motion phenomena, predict the effects of a force, and interpret observations scientifically. Dynamics, therefore, is a relevant topic for assessing students' scientific literacy levels. If dynamics learning focuses solely on mathematical calculations, then the dimensions of students' scientific literacy, particularly those related to explaining phenomena and interpreting evidence, have the potential to under-develop. Therefore, learning this material requires the support of teaching materials and learning models that can facilitate a more structured scientific learning experience.

One alternative that can be used to support these needs is the Student Worksheet. Student Worksheet is a teaching material that can guide students in carrying out learning activities in a structured manner through work instructions, guiding questions, observation activities, analysis of results, and drawing conclusions. In physics learning, Student Worksheet can help students learn more actively because it not only contains a summary of the material but is also designed to facilitate the scientific thinking process. However, the effectiveness of Student Worksheet is greatly influenced by the underlying learning model. Student Worksheet that only contains practice questions without clear thinking stages will not necessarily be able to develop students' scientific literacy. Therefore, Student Worksheet must be designed based on a learning model that allows for prediction, observation, and scientific explanation activities to align with scientific literacy indicators.

The Predict–Observe–Explain (POE) model is a relevant learning model to be integrated into student worksheets because it consists of structured stages that align with the scientific process. In the predict stage, students formulate initial predictions based on prior knowledge, in the observe stage they conduct observations or experiments to test these predictions, and in the explain stage they construct explanations based on observations and appropriate scientific concepts. This process enables students to activate prior knowledge, identify discrepancies between predictions and observations, and reconstruct their understanding scientifically. Several studies have shown the effectiveness of the POE model in improving the quality of science learning, where Tüysüz and Demir (2023) reported that POE has a positive effect on students' conceptual understanding, while Pektaş and Özdemir (2024) found that POE supported by simulations enhances students' critical thinking skills. In addition, POE-based teaching materials have been shown to promote student engagement and support higher-order thinking skills (Elviana et.al., 2024). Therefore, the POE model is considered appropriate as a basis for designing student worksheets that are more oriented toward the development of scientific literacy in physics learning.

Other relevant research shows that the use of learning models that provide opportunities for scientific activities has a positive impact on students' science process skills and conceptual understanding. Fiteriani et.al., (2023) stated that the implementation of the POE model can improve students' understanding of scientific concepts and process skills, while Zulhelmi et al. (2023) reported that POE supported by learning media can enhance students' learning activities in a more active and interactive manner. In addition, studies on teaching materials in physics indicate that students need materials that not only present content but also facilitate concept exploration, connect theory with real phenomena, and support independent information processing. These findings suggest that the development of appropriate teaching materials plays a significant role in improving the quality of physics learning. However, most previous studies have focused on testing the effectiveness of models or products, while research that specifically examines students' initial scientific literacy conditions and the need for POE-based worksheets in dynamics learning at the high school level is still limited.

These limitations of previous research serve as the primary basis for this research. Many studies have demonstrated the superiority of POE for learning outcomes, conceptual understanding, science process skills, or critical thinking skills, but few studies have begun with an analysis of students' initial conditions and an analysis of their teaching material needs as a basis for development. This initial analysis is crucial to ensure that the teaching materials designed truly align with student characteristics, classroom learning needs, and the demands of the material to be studied. Therefore, the novelty of this research lies in its focus, which does not directly test the effectiveness of the product, but rather first analyzes students' scientific literacy levels and the needs of Predict-Observe-Explain (POE)-based worksheets for dynamics learning in high school. This focus provides a stronger and more contextual basis for Student Worksheet development, so that the products developed are not only attractive in design but also relevant to real-life learning problems.

Based on the description, this study is directed to answer two main problem formulations, namely how is the level of scientific literacy of students in learning dynamics in high school and how is the need for POE-based Student Worksheet to support learning dynamics. Therefore, the purpose of this study is to analyze the level of scientific literacy of students and analyze the need for Predict-Observe-Explain (POE)-based Student Worksheet in learning dynamics in high school. This study is expected to provide theoretical benefits in the form of strengthening studies on the relationship between scientific literacy, the need for teaching materials, and the POE model in physics learning. In addition, this study is expected to provide practical benefits as a basis for developing POE-based Student Worksheet that are more appropriate to student characteristics, learning needs, and the demands of dynamics material, so that it can support physics learning that is more active, scientific, and oriented towards strengthening students' scientific literacy.

METHODS

Types of Research

This research is a descriptive study with quantitative and qualitative approaches. The quantitative approach was used to analyze the level of students' scientific literacy through a scientific literacy test on dynamics material, while the qualitative approach was used to analyze the need for the development of Predict-Observe-Explain (POE)-based Student Worksheets through document analysis, student needs questionnaires, and interviews with 2 teachers. This research is a preliminary study that aims to obtain an overview of the initial conditions of physics learning, especially those related to students' scientific literacy abilities and the need for appropriate teaching materials for dynamics learning in high school.

Time and Place of Research

This research was conducted on February 23, 2026, at MAN Kota Pariaman, West Sumatra. The study involved grade XI students of Phase F in physics learning, particularly on dynamics material. The selection of this research site was based on its relevance to the focus of the study, which is the analysis of students’ scientific literacy. In addition, the research also aimed to identify the need for POE-based student worksheets in physics learning at the senior high school or Islamic senior high school level. Therefore, the chosen location is considered appropriate to support the objectives of this study.

Research subjects

The subjects of this study were 30 students of grade XI Phase F2 of MAN Kota Pariaman in the 2025/2026 academic year who participated in physics learning on dynamics material. Students were the main subjects in measuring the level of scientific literacy and analyzing learning needs. In addition, physics teachers of grade XI and grade X were also used as data sources to obtain information regarding the learning process, use of teaching materials, student characteristics, and the need for developing POE-based Student Worksheet. The determination of subjects was carried out using a purposive sampling technique, namely the selection of subjects based on considerations of suitability with the research objectives, especially direct involvement in dynamics learning.

Research Procedures

This research was conducted in three stages: preparation, data collection, and data analysis. During the preparation stage, the researcher conducted a literature review on scientific literacy, the PISA 2022 framework, student worksheets, the POE learning model, and dynamics material. This stage aimed to strengthen the theoretical foundation and serve as the primary basis for developing the research instruments. The instruments developed in this study included a scientific literacy test, a Student Worksheet document analysis sheet, a student needs analysis questionnaire, and interview guidelines with two teachers.

The data collection phase was conducted using several techniques. First, the researcher administered a scientific literacy test to 30 grade XI students in Phase F2 to obtain an overview of students' scientific literacy levels in dynamics. The test was designed based on the PISA 2022 framework, which covers three main competencies: explaining phenomena scientifically, evaluating and designing scientific investigations, and interpreting scientific data and evidence. Second, the researcher analyzed the Student Worksheet documents previously used by teachers in physics learning. This analysis was conducted to examine the suitability of the Student Worksheet with the characteristics of proper physics learning, especially in facilitating students' scientific activities. Third, the researcher distributed questionnaires to students to obtain information about their needs for physics learning, the application of learning models and teaching materials used. Fourth, the researcher conducted interviews with two physics teachers to obtain more in-depth information regarding the implementation of learning, the use of Student Worksheet, student characteristics, and the condition of students' scientific literacy.

The data analysis phase was conducted after all data were collected. Quantitative data from the science literacy test were analyzed to describe students' ability levels in each science literacy competency. Meanwhile, qualitative data from document analysis, questionnaires, and interviews were analyzed to identify the need for developing POE-based student worksheets for dynamics learning. The analysis results from all data sources were integrated to provide a comprehensive picture of the initial conditions of physics learning and the need for appropriate teaching materials.

Research Data and Instruments

The research data consists of quantitative and qualitative data. The quantitative data are student science literacy test scores on dynamics. This data is used to determine students' scientific literacy levels based on the scientific literacy competencies within the PISA 2022 framework. The qualitative data include analysis of student worksheet documents previously used by teachers, student needs questionnaires, and interviews with physics teachers. These qualitative data are used to uncover the need for developing POE-based worksheets for dynamics teaching.

The research instruments used consisted of four types. The first instrument was a scientific literacy test designed based on scientific literacy competencies within the PISA 2022 framework. The second instrument was a student worksheet document analysis sheet, used to examine student worksheets previously used by teachers in terms of content, activity steps, learning activities, and their suitability for physics learning, which emphasizes student engagement in scientific activities. The third instrument was a student needs analysis questionnaire, used to determine students' needs for physics learning activities, the application of learning models, and expected teaching materials. The fourth instrument was an interview guide with teachers, used to obtain information regarding the learning process, use of teaching materials, learning obstacles, and teachers' views on students' scientific literacy abilities.

Data Collection Technique

Data collection in this study was conducted through tests, document analysis, questionnaires, and interviews. The test was administered to 30 grade XI Phase F students on February 23, 2026, to measure their scientific literacy in dynamics. Document analysis was carried out on previously used Student Worksheet to examine their suitability with scientific learning activities. Questionnaires were distributed to identify students' needs, indicating that they prefer more engaging learning through experiments and hands-on activities. Interviews with physics teachers revealed that learning is still dominated by concept explanation, with limited opportunities for observation and scientific reasoning, resulting in relatively low students' scientific literacy skills.

Data Analysis Techniques

The data in this study were analyzed using quantitative and qualitative approaches. Quantitative analysis was conducted on the scientific literacy test results by calculating students' scores and grouping them based on the three competencies in the PISA 2022 framework, namely explaining phenomena scientifically, evaluating and designing scientific investigations, and interpreting scientific data and evidence. The scores for each competency were then converted into percentages to describe students' levels of scientific literacy in dynamics learning. Meanwhile, qualitative data from document analysis of student worksheets, questionnaires, and interviews were analyzed descriptively through data reduction, data presentation, and conclusion drawing. Data reduction focused on selecting information relevant to the development of POE-based Student Worksheet, while data were presented in narrative form to clearly describe the patterns of findings.

RESULTS AND DISCUSSION

Results

The results of the scientific literacy test were obtained from 30 11th-grade Phase F students on dynamics. The test was designed based on the PISA 2022 framework, which emphasizes three core competencies in scientific literacy: explaining phenomena scientifically, evaluating and designing scientific investigations, and interpreting scientific data and evidence. Within this framework, scientific literacy is understood not only as mastery of concepts but also as the ability to use scientific knowledge to understand phenomena, assess the investigation process, and draw conclusions based on evidence (OECD, 2023).

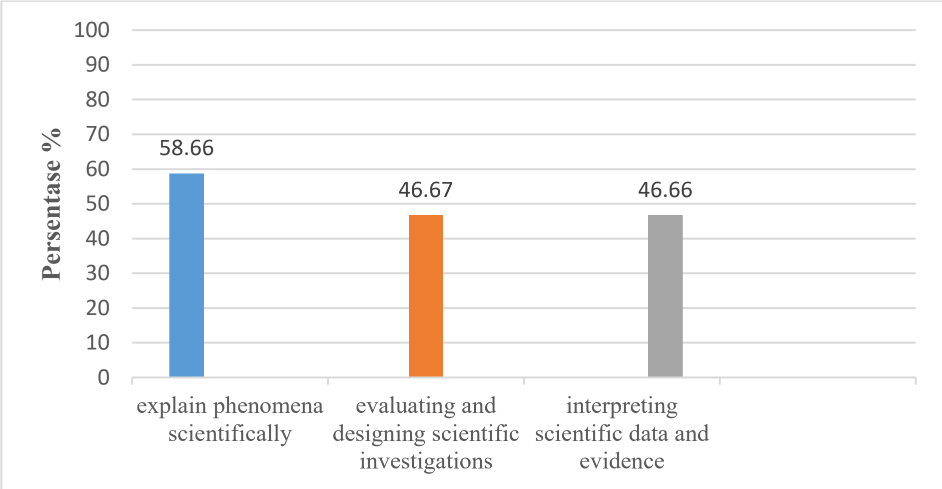

Figure 1. Results of Students' Science Literacy Test

The test results show that students' ability to explain phenomena scientifically reached an average of 58.66%, indicating that some students were able to relate physics concepts to given phenomena, although their explanations were often not coherent and lacked strong scientific reasoning. Meanwhile, the competency of evaluating and designing scientific investigations was lower, with an average of 46.67%, showing that students had difficulties in understanding experimental design, determining variables, and evaluating procedures. This suggests that students are not yet accustomed to engaging in systematic scientific investigations and tend to receive concepts directly rather than constructing them through inquiry. According to the PISA 2022 framework, this competency is essential as it reflects students' ability to understand how scientific knowledge is developed (OECD, 2023).

The ability to interpret scientific data and evidence achieved an average of 46.66%, indicating that students had difficulty interpreting data and relating it to appropriate physics concepts. Students tended to recognize surface information but were not yet able to draw meaningful scientific conclusions or use evidence to support explanations. This competency is essential in scientific literacy as it reflects students' ability to understand and validate scientific knowledge (OECD, 2023). Compared to other competencies, explaining phenomena scientifically showed higher achievement, while evaluating investigations and interpreting data remained lower. Overall, these findings indicate that students' scientific literacy in dynamics learning is still suboptimal, particularly in aspects related to scientific processes and evidence-based reasoning.

Document analysis of previously used student worksheets shows that the materials were still focused on presenting conceptual summaries and practice problems, and had not yet facilitated scientific activities in physics learning. The worksheets did not optimally guide students to predict, observe, and explain phenomena based on evidence, indicating that they functioned more as practice tools rather than as materials supporting the scientific process. This condition suggests that the teaching materials were not fully aligned with the characteristics of physics learning, which emphasizes observation, reasoning, and evidence-based explanation. In contrast, POE-based worksheets have been shown to better support student engagement and higher-order thinking skills (Elviana et.al., 2024).

Analysis of student needs was conducted through a questionnaire to obtain information on students' perceptions of the physics learning they experience and the types of learning activities they expect. The questionnaire results provide an overview of students' preferences toward more engaging and meaningful learning processes. These findings are important as a basis for designing learning materials that align with students' needs and characteristics. The summary of the questionnaire results is presented in Figure 2.

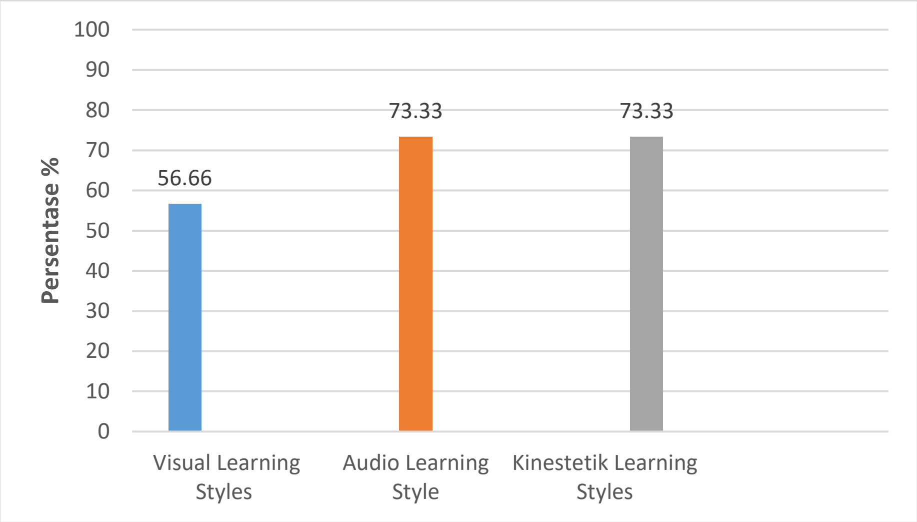

Figure 2. Results of student learning style analysis

The data processing results showed that there were 56,66% students with a visual learning style, lower than the other two groups. This indicates that some students tend not to rely solely on sight to understand the material, but require other stimuli to maximize learning. Meanwhile, the number of auditory and kinesthetic learning styles was the same, namely 73,33% students. This finding illustrates that most students learn more effectively through oral explanations, discussions, or listening to teacher presentations, as well as through physical activities such as practice, experiments, observations, simulations, and direct activities in the field or laboratory. The dominance of auditory and kinesthetic learning styles indicates that learning that prioritizes verbal interaction and practical activities will have a greater impact on student understanding. In general, it can be concluded that the majority of students show a tendency towards auditory and kinesthetic learning styles, so that learning strategies that combine oral explanations with direct experience activities are considered more relevant to increasing their active engagement and learning outcomes.

The analysis of student learning preferences was conducted through a questionnaire to identify students' interests in various learning models used in physics learning. The questionnaire results indicate that students tend to prefer learning models that actively involve them, especially those based on experiments and direct practice. In addition, other learning models such as Problem-Based Learning, digital-based independent learning, and Project-Based Learning also show varying levels of student interest. The detailed results of students' preferences toward learning models are presented in Figure 3.

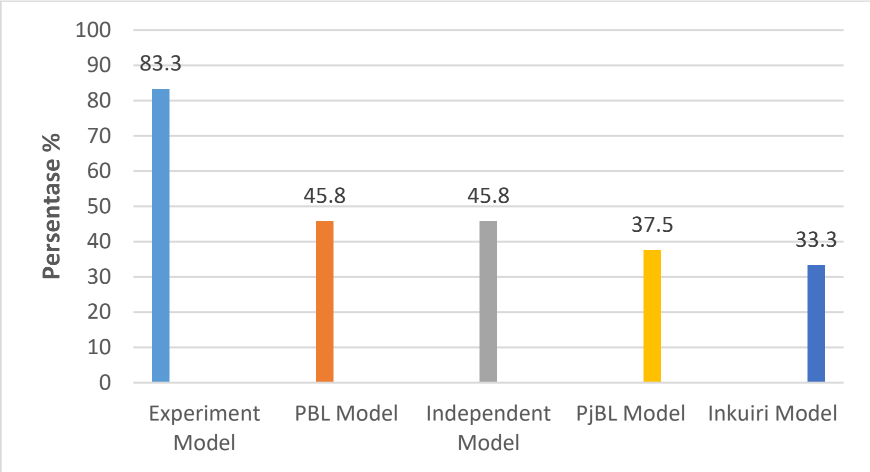

Figure 3. Results Of Implementation of Learning Model

The questionnaire results show that most students prefer experiment-based learning (83.3%), followed by Problem-Based Learning and digital-based independent learning (45.8%), Project-Based Learning (37.5%), and inquiry as the least preferred (33.3%). Overall, students tend to desire more active, engaging, and challenging learning involving experiments and direct observation, as these activities help them better understand concepts compared to teacher-centered instruction. This need aligns with the characteristics of the POE model, which encourages students to actively predict, observe, and explain phenomena (Samya et al., 2024). Meanwhile, teacher interviews reveal that physics learning is still dominated by conceptual explanations, with limited opportunities for students to engage in observation and explanation processes. As a result, students tend to accept information passively and show low scientific literacy, particularly in explaining phenomena and interpreting data. Therefore, both student needs and teacher perspectives indicate the importance of developing teaching materials that support active, scientific process-based learning.

Discussion

The results of this study indicate that students' scientific literacy in dynamics learning remains low, particularly in evaluating and designing scientific investigations and interpreting data and evidence. Students tend to focus more on conceptual understanding rather than applying knowledge in scientific processes. Although some students are able to explain phenomena scientifically, this ability has not yet developed into inquiry and evidence-based reasoning skills. This condition is not yet aligned with the PISA 2022 framework, which emphasizes the integration of conceptual knowledge, scientific processes, and evidence interpretation (OECD, 2023). These findings are consistent with Apriyani, Fadilah, and Wahyuni (2021), who reported that learning models significantly influence students' scientific literacy, indicating that current learning practices have not fully supported the development of comprehensive scientific literacy.

Furthermore, the analysis of student worksheets reveals that existing teaching materials are still focused on concept delivery and problem-solving, and have not facilitated systematic scientific thinking processes such as predicting, observing, and explaining based on evidence. This finding supports Elviana et al. (2024), who demonstrated that POE-based worksheets can enhance student engagement and higher-order thinking skills. In addition, questionnaire results show that students prefer more active, challenging, and experiment-based learning, which is in line with studies by Samya et al. (2021) and Pektaş and Özdemir (2024) highlighting the effectiveness of the POE approach in improving engagement and critical thinking. Teacher interviews further reveal that learning remains teacher-centered, limiting students' involvement in scientific processes. Therefore, this study highlights the importance of conducting a needs analysis as a foundation for developing POE-based worksheets that are contextual and relevant to support students' scientific literacy.

CONCLUSION

This study shows that the scientific literacy of eleventh-grade students in Phase F on dynamics learning has not yet developed optimally, particularly in the ability to design or evaluate scientific investigations and interpret scientific data and evidence. Students tend to be more capable of explaining phenomena based on previously learned concepts, but are not yet accustomed to constructing understanding through scientific processes involving prediction, observation, and evidence-based explanation. These findings indicate that current learning practices still emphasize conceptual mastery rather than the comprehensive development of scientific literacy. Furthermore, the analysis reveals a strong need for the development of Predict–Observe–Explain (POE)-based student worksheets in physics learning. Existing student worksheets have not fully facilitated scientific activities, while students express a preference for more active and experiment-based learning. In addition, teachers report that learning is still dominated by conceptual explanations, causing students to receive information passively without testing it through scientific processes. Therefore, this study highlights that the development of POE-based student worksheets is not only theoretically relevant but also grounded in real classroom needs, and has the potential to support more active, contextual, and scientifically oriented physics learning.

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