Development of a Problem-Based Physics Teaching Module to Enhance Students' Science Process Skills

Rabiatul Hasanah[1], Gunawan[2], Muntari[3], Joni Rokhmat[1], & Ahmad Harjono[1]
[1]Science Education Master Program, University of Mataram, Indonesia
[2]Physics Eduation Study Program, University of Mataram, Indonesia
[3]Chemistry Education Study Program, University of Mataram, Indonesia
*Corresponding Author: rabyatul267@gmail.com

Received: 13th January 2025; **Accepted**: 23rd May 2025; **Published**: 18th June 2025
DOI: https://dx.doi.org/10.29303/jpft.v11i1.8384

Abstract - *This study aims to develop a valid, practical, and effective problem-based physics teaching module to enhance students' science process skills (SPS). The research employs a Research and Development (R&D) approach using the 4D development model, which includes the stages of Define, Design, Develop, and Disseminate—limited in this case to dissemination among physics teachers. The Develop stage involved the creation of the teaching module as well as validation, practicality, and effectiveness testing. The module was evaluated by three expert validators to assess its validity. Practicality was measured through student and teacher responses and the implementation of the learning process, involving 18 students from Class XI IPA 1 at a high school in Pringgabaya District. Effectiveness testing used a one-group pretest-posttest design and included 36 students from Classes XI IPA 2 and 3 at the same school. Data collection instruments included validation sheets, teacher and student response questionnaires, lesson implementation observation sheets, and SPS questionnaires. Data were analyzed using Aiken's V index, percentage calculations, and the N-Gain test. The validation results showed that both the module and instruments had average validity ratings categorized as "highly valid" (Aiken's V > 0.80). In terms of practicality, student responses averaged 96.39%, teacher responses averaged 92.95%, and the implementation of the three learning sessions averaged 88.88%. Effectiveness results indicated that the module was moderately effective in improving science process skills, with an N-Gain score of 0.65 (medium category) and an effectiveness rate of 65.71%. It can thus be concluded that the Problem-Based Physics Teaching Module is valid, practical, and moderately effective in enhancing students' science process skills.*

Keywords*: Physics Teaching Module; Problem-Based Learning; Science Process Skills*

INTRODUCTION

Education plays a vital role in human life and the development of a nation. It is a fundamental need, as it enables individuals to learn, understand various issues, and achieve well-being (Triwiyanto, 2021). In the context of national education, the curriculum serves as the "soul" of education and must be continuously evaluated in innovative and dynamic ways to keep pace with societal changes and the demands of the workforce (Wati et al., 2023).

The *Merdeka Curriculum* emphasizes student-centered learning while instilling the values outlined in the *Profil Pelajar Pancasila* (Pancasila Student Profile), which includes being faithful and devoted to God, embracing global diversity, working collaboratively, being independent, creative, and critical thinkers (Triwiyanto, 2021). Cultivating these qualities requires instructional approaches that support holistic development, particularly critical thinking and science process skills.

However, physics education in Indonesia continues to face significant challenges. One of the main issues is the low level of students' science process skills. These skills include the ability to formulate problems, design experiments, analyze data, and draw conclusions (Putri, 2024). Such competencies are essential for nurturing independent and critical thinkers (Rahman, 2022).

Several factors contribute to the underdevelopment of science process skills, including: (1) teacher-centered instructional practices; (2) limited use of innovative teaching media; (3) lack of relevant learning resources; and (4) teachers' limited capacity to design engaging and contextualized lessons (Prasetyo & Nurhadi, 2020; Sari, 2021; Permendikbud, 2020; Susanti, 2023).

Interviews with a physics teacher at a high school in Pringgabaya District revealed that students tend to be passive during lessons. Teachers rarely use the Problem-Based Learning (PBL) model and often neglect to assess psychomotor domains such as science process skills. Teaching modules are commonly sourced from the internet and often lack proper validation. Teachers also expressed difficulty in designing modules that align with the Merdeka Curriculum.

One promising solution is the development of problem-based physics teaching modules. Problem-Based Learning emphasizes solving authentic, relevant problems, encouraging students to actively construct knowledge and skills (Hidayat, 2023). This approach is effective for improving science process skills because it involves students directly in scientific inquiry.

Teaching modules themselves are structured learning tools designed to help teachers achieve learning goals in a systematic way (Maylitha et al., 2023). Developing such modules requires pedagogical expertise to ensure that learning is focused, efficient, and aligned with intended outcomes. Unfortunately, there is still a lack of research specifically focused on designing problem-based physics modules aimed at enhancing science process skills within the framework of the Merdeka Curriculum.

Developing problem-based teaching modules allows students to learn collaboratively and reflectively, with teachers acting as facilitators who guide students through the inquiry process (Rizaldi & Syahwin, 2023). Assessment can be carried out using various methods such as projects, presentations, and formative evaluations, all of which support continuous improvement in science process skills (Fitriyani & Suparwoto, 2021).

Therefore, this study aims to develop a valid, practical, and effective problem-based physics teaching module to enhance students' science process skills. The module is expected to offer a meaningful solution to the current challenges in physics instruction while supporting the contextual and optimal implementation of the Merdeka Curriculum.

RESEARCH METHODS

This study employed a Research and Development (R&D) approach. The research followed the 4D development model, which consists of four main stages: Define, Design, Develop, and Disseminate.

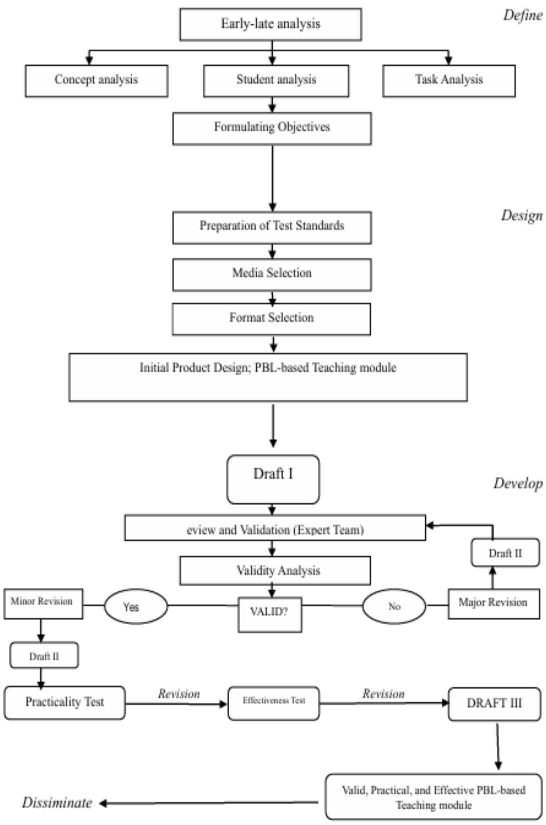

Figure 1. Development Procedure

The *Develop* stage focused on evaluating the product through validation, practicality, and effectiveness testing. Before the developed product was put into use in the field, expert validation was done to make sure it was legitimate. The science process skills (SPS) questionnaire, the teaching module, and the student worksheet were all reviewed by experts as part of this validation process. Validation questionnaires were used to gather data, and Aiken's V formula was used for analysis. The criteria listed in Table 1 were used to determine the level of validity.

Table 1. Teaching Module Validation Level

Range	Criteria
$V \leq 0,4$	Not Valid
$0,4 < V < 0,8$	Valid
$V \geq 0,8$	Strong Valid

(Aiken, 1997)

The purpose of the practicality test was to get direct feedback from both students and teachers on the physics module and other learning tools that go along with it. For this phase, 18 eleventh-grade students from a high school in the Pringgabaya District were tested. We used three tools to gather data: the learning implementation observation sheet, the teacher response questionnaire, and the student response questionnaire. Percentage analysis was used to look at the results. Table 2 shows the criteria for practicality.

Table 2. Practicality Level Criteria

Percentage of practicality	Criteria
75,01 – 100	Very practical
50,01 – 75,00	Fairly practical
25,01 – 50,00	Slightly practical
≤ 25,00	Not practical at all

(Marisa et al., 2020)

The effectiveness test evaluated how well the problem-based physics module enhanced students' science process skills. This test was conducted with 36 eleventh-grade science students from a high school in Pringgabaya District using a one-group pretest-posttest design. In this design, students took a pretest before the intervention and a posttest afterward (see Table 3).

Table 3. *One Group Pretest-Posttest* Design

Pre-Test	Treatment	Post-Test
O1	X	O2

Description:
O_1 : Pretest administered to assess students' SPS prior to instruction
X : Instruction using the Problem-Based Physics Teaching Module
O_2 : Posttest administered to assess students' SPS after instruction

Data were collected using a questionnaire, and the results were analyzed using the N-Gain formula. N-Gain criteria are presented in Table 4, while the standard interpretation of effectiveness based on N-Gain is outlined in Table 5.

Table 4. *N-gain* Criteria

N-gain Score (%)	Category
$g > 0,7$	High
$0,3 \leq g \leq 0,7$	Medium
$g < 0,3$	Low

(Hake,1998)

Table 5. Standard Interpretation of N-gain Effectiveness

N-gain Score (%)	Category
< 40	Not effective
40-55	Less effective
56-75	Fairly effective
> 76	Effective

(Taufik & Doyan, 2022)

RESULTS AND DISCUSSION

This study resulted in the development of a problem-based physics teaching module aimed at improving students' science process skills and learning outcomes. The module was developed, implemented, and tested with students in a classroom setting. Data from the field trials were analyzed to evaluate the improvement in students' science process skills and learning outcomes after participating in lessons using the problem-based physics module.

Results

1. Validation Results

The purpose of the validation process is to gather expert feedback on the quality of the developed product. The critiques and suggestions provided by the experts regarding the weaknesses and shortcomings of the teaching module serve as the basis for further refinement, ensuring the product is valid and suitable for instructional use. In addition to the teaching module, the experts also evaluated the ATP (Teaching Implementation Plan), student worksheets, learning outcome assessment instruments, and the science process skills questionnaire. A summary of the validation results is presented below:

Table 6. ATP Validation Results

No	Components	Aiken's V Index	Description
1	Content Feasibility	0,82	Highly Valid
2	Presentation Feasibility	0,80	Highly Valid
3	Presentation Feasibility	0,83	Highly Valid

Table 6 shows that the content feasibility aspect received an index score of 0.82, presentation feasibility scored 0.80, and language feasibility reached 0.83. All of these components fall within the *Highly Valid* category, indicating that the Teaching Implementation Plan (ATP) substantially meets the validity criteria. These scores suggest that the ATP is presented in a systematic manner, with clear and easily understandable language.

Table 7. Teaching Module Validity Test Results

No	Komponen	Indeks Aiken's V	Keterangan
1	Content Feasibility	0,84	Highly Valid
2	Presentation Feasibility	0,84	Highly Valid
3	Presentation Feasibility	1	Highly Valid

Table 7 presents the results of the validation analysis for the Teaching Module. The content feasibility aspect achieved an Aiken's V index of 0.84, presentation feasibility also scored 0.84, and language feasibility received a perfect score of 1. All components fall within the *Highly Valid* category, indicating that the teaching module fully meets the established validity criteria.

Table 8. Student Worksheet Validity Test Results

No	Components	Aiken's V Index	Description
1	Content Feasibility	0,83	Highly Valid
2	Presentation Feasibility	0,79	Valid
3	Presentation Feasibility	0,79	Valid

Table 8 presents the results of the validation analysis for the student worksheet. The content feasibility aspect achieved an Aiken's V index of 0.83, placing it in the *Highly Valid* category. Meanwhile, both presentation feasibility and language feasibility scored 0.79, which falls into the *Valid* category. These results indicate that the student worksheet demonstrates good quality in terms of content, presentation, and language. Although the overall validity is satisfactory, further improvements in presentation and language aspects could enhance the student worksheet even further.

Table 9. Validity Test Results of the Science Process Skills Instrument

No	Components	Aiken's V Index	Description
1	Prediction	0,85	Highly Valid
2	Inference	0,85	Highly Valid
3	Identifying Variables	0,79	Valid
4	Formulating Hypotheses	0,79	Valid
5	Data Interpretation	0,81	Highly Valid
6	Designing Experiments	0,79	Valid

The analysis results show that the prediction and inference aspects each achieved an Aiken's V index of 0.85, while data interpretation scored 0.81 — all of which fall into the Highly Valid category. Meanwhile, variable identification, hypothesis formulation, and experimental design each scored 0.79, placing them in the Valid category. These results indicate that the Science Process Skills (SPS) instrument has good overall validity, with several particularly strong components for assessing science process skills. However, further refinement of the variable identification, hypothesis formulation, and experimental design components could enhance the overall quality of the instrument.

2. Practicality Test Results

The practicality test was conducted after the teaching module and learning tools were validated. The goal of this test was to gather direct feedback from students and teachers regarding the practicality of the teaching module and instructional instruments. Practicality was assessed using percentage-based criteria, with the following four categories: *practical*, *fairly practical*, *less practical*, and *not practical*.

a. Student Response Results

Student responses evaluated the practicality of several aspects, including the learning activities, instructional materials, and the student worksheets, all designed to enhance learning outcomes and science process skills. The results of the student responses are shown in Figure 2:

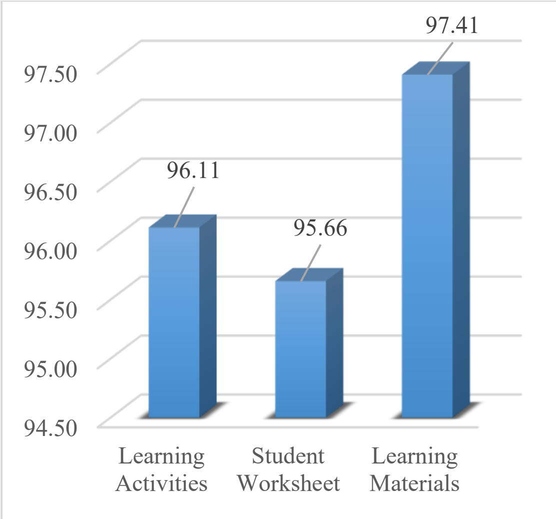

Figure 2. Student responses

Figure 2 shows the results of student responses across three aspects: learning activities, student worksheets, and instructional materials. *Instructional materials* received the highest rating at **97.41%**, indicating that this aspect was perceived as the most effective and practical. *Learning activities* followed closely with **96.11%**, also reflecting a highly practical implementation. *Student worksheet* received a slightly lower score of **95.66%**, but still falls within the *practical* category. Overall, these three aspects garnered very positive ratings, with only minor differences in percentage, suggesting that all components were well-designed and effectively implemented.

b. Teacher Response Results

Teacher responses assessed the practicality of several aspects, including Initial activities, the teaching module, learning materials, student worksheet, learning outcome instruments, and the science process skills (SPS) instrument. The results of the teacher responses are shown in Figure 3.

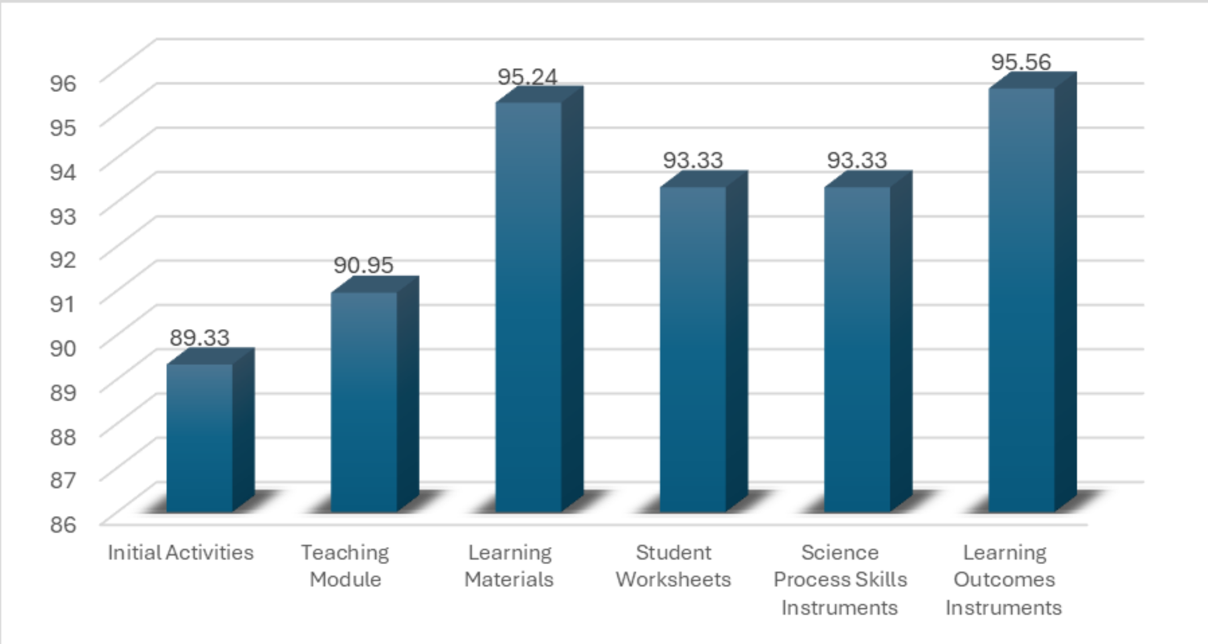

Figure 3. Teacher Responses in Percentage

Figure 3 presents the results of teacher responses across six evaluation aspects. Initial activities received the lowest rating at 89.33%, indicating a need to improve the design of opening activities to make them more effective and engaging. The teaching module was rated fairly well at 90.95%, though there is still room for enhancement to better support student understanding. In contrast, learning materials received a high rating of 95.24%, followed by the learning outcome instrument, which achieved the highest rating at 95.56%, reflecting its strong quality in helping achieve learning objectives. Both the student worksheet and SPS instrument scored 93.33%, demonstrating solid effectiveness, although further evaluation could be conducted to refine these components.

3. Effectiveness Test Results

The purpose of the effectiveness test is to analyze how effective the problem-based physics teaching module is in improving students' science process skills and learning outcomes. The effectiveness test involved **36 students** as the experimental group. The results of the effectiveness test are as follows:

a. Pre-Test and Post-Test Results for Science Process Skills (SPS)

Science process skills were measured using a questionnaire. The questionnaire was developed based on specific SPS indicators and administered both before (*pre-test*) and after (*post-test*) the learning intervention. The percentages of pre-test and post-test results for science process skills are shown in Figure 4.

Figure 4 shows an increase in students' science process skills across all indicators. Prior to instruction, pre-test scores ranged from **44.44% to 51.39%**, indicating relatively low initial skill levels. After instruction, post-test scores increased substantially, ranging from **72.22% to 88.19%**. The *observing* indicator achieved the highest post-test score at **88.19%**, followed by *experimenting* at **86.11%**. The *predicting* indicator showed the smallest improvement, with a post-test score of **72.22%**. Overall, these results demonstrate improvement across all SPS indicators.

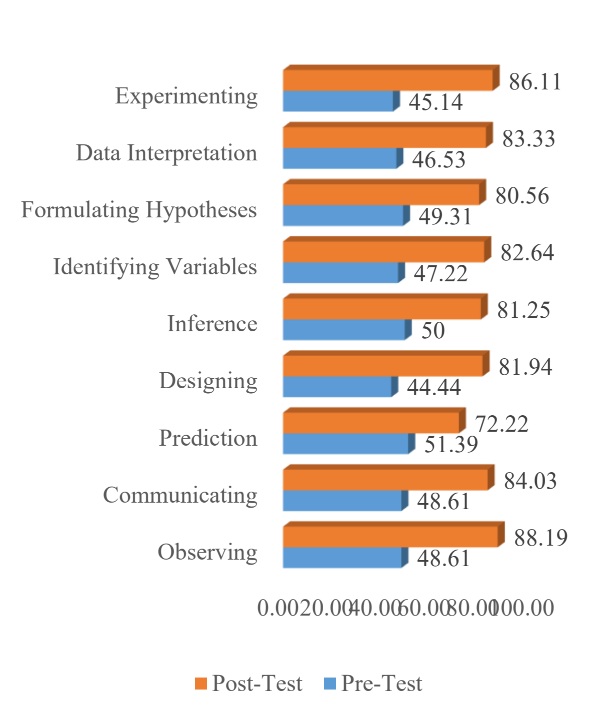

Figure 4. Percentage Results of Science Process Skills by Indicator

b. N-Gain Results for Science Process Skills (SPS)

The N-gain provides a general overview of the improvement in science process skills scores before and after the implementation of the Problem-Based Physics Teaching Module. The improvement was calculated based on the difference between pre-test and post-test scores, normalized against the maximum possible score difference and the students' pre-test scores. The N-gain results for SPS are presented in Table 10:

Table 10. Summary of N-gain Results for Science Process Skills

No	Component	Result	Category
1	N-Gain Score	0,65	Medium
2	Standard Interpretation of N-Gain Effectiveness	65,71%	Fairly Efective

Table 10 summarizes the N-gain results for science process skills (SPS), which were analyzed to assess the effectiveness of the instruction. The overall N-gain score was 0.65, falling into the moderate category, indicating that students' science process skills improved following the implementation of the problem-based physics teaching module.

Figure 4 shows the N-gain analysis results for each individual SPS indicator. The indicators with the highest N-gain scores were observing (0.77) and experimenting (0.75), both classified as high and interpreted as effective and fairly effective. Most of the other indicators — including communicating, designing, inferring, identifying variables, formulating hypotheses, and interpreting data — had N-gain scores within the moderate range, indicating fairly effective instruction. However, the predicting indicator recorded an N-gain score of 0.43, which is still within the moderate category but interpreted as less effective. These results suggest that the instruction was successful in improving SPS across most indicators, though the predicting indicator requires additional attention to further enhance instructional effectiveness.

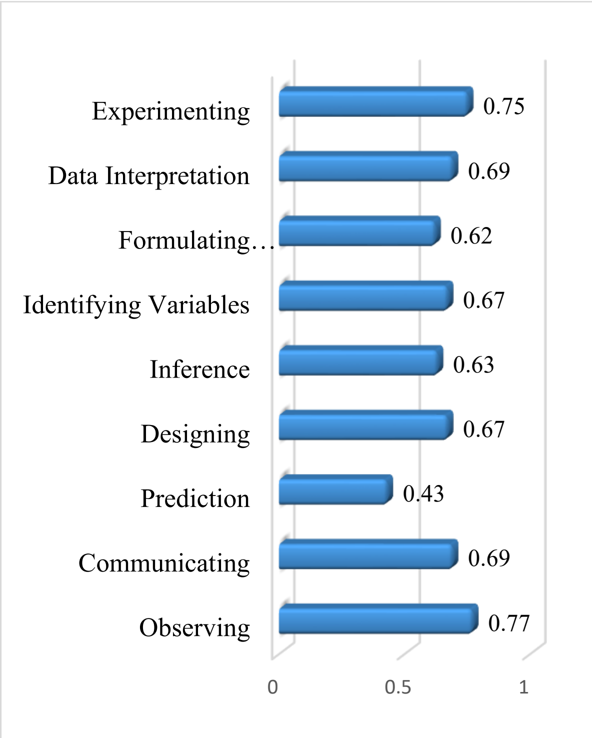

Figure 5. N-Gain Scores of Science Process Skills by Indicator

Discussion

1. Validity of the Problem-Based Physics Teaching Module

The validity test (expert appraisal) aims to ensure the module is a sound and reliable product, evaluated through expert reviews. This validation process includes content validity and construct validity. Content validity assesses how well the instrument captures all relevant aspects of the concept being measured (Nengsih et al., 2019). In this study, content validity covers the alignment of the teaching module and learning tools with the problem-based learning (PBL) model and their relevance to science process skills (SPS) and learning outcomes.

Construct validity focuses on the structure, organization, language, and visual presentation of the instrument (Nengsih et al., 2019). The instrument's components must be logically and systematically organized so that all parts contribute coherently to the intended concept. Clear, age-appropriate language is essential to avoid ambiguity or misinterpretation. Additionally, visual elements such as images, diagrams, and layouts should support conceptual understanding rather than distract from it (Flake et al., 2017).

The results of the validity test, using Aiken's V index, indicate that the learning objectives flow chart demonstrates very high validity across three components: content suitability (0.82), presentation quality (0.80), and language quality (0.83). These results confirm that the flow of learning objectives is well-designed and pedagogically sound. The clarity of language and structure further enhances the module's usability by educators, echoing findings from prior studies that highlight the importance of strong content, presentation, and language validity in effective learning tools (Dzikro & Dwiningsih, 2021).

The teaching module itself also shows excellent validity, with Aiken's V scores of 0.84 for both content and presentation, and a perfect 1.00 for language quality. This reflects that the module fully meets the "highly valid" criteria across all aspects. Strong language validity is particularly important, as clear and communicative language significantly supports students' comprehension (Maulida, 2022). Therefore, this teaching module is highly suitable for use in the classroom to help achieve learning goals.

In the context of the Merdeka Curriculum, the teaching module offers flexibility for teachers to design adaptive lessons tailored to student needs—especially valuable in physics education. The development of this problem-based physics teaching module holds great potential to enhance students' SPS and learning outcomes. The PBL approach fosters critical thinking, problem-solving, and practical application of scientific concepts, aligning with the curriculum's emphasis on relevant, contextual learning (Maulida, 2022).

Focusing on SPS through a problem-based approach aligns with research showing that PBL can strengthen students' abilities in observation, data analysis, and scientific communication (Fauziah, 2022). This is especially critical in physics, where experimentation and hypothesis testing are integral. The module also incorporates formative assessments to monitor students' progress in SPS. Thus, this module not only improves academic achievement but also equips students with essential scientific skills for everyday life (Salsabilla et al., 2023).

The validity test for the student worksheet resulted in an Aiken's V score of 0.83 for content validity ("highly valid"), while presentation and language scored 0.79 ("valid"). Although the overall validity is strong, there is room for improvement in presentation and language to further enhance the student worksheet's effectiveness in fostering SPS and learning outcomes. This aligns with Rohmah et al. (2021), who emphasized the importance of clear presentation and language in maximizing the educational value of worksheets.

The SPS instrument showed very high validity in the prediction and inference aspects (both at 0.85), as well as data interpretation (0.81). Other components, such as identifying variables, formulating hypotheses, and designing experiments, were rated as "valid" with scores of 0.79. These results indicate that the SPS instrument is generally effective, although certain aspects could be improved for more comprehensive assessment of students' skills. Previous studies also stress that instrument validity is crucial for ensuring reliable data collection in SPS evaluations (Ramadani et al., 2017).

The learning outcomes test instrument also demonstrated strong validity, with scores of 0.89 for content, 0.86 for construct, and 0.83 for language—all classified as "highly valid." This confirms that the instrument is well-suited for measuring learning outcomes. High content validity ensures the test aligns with learning objectives, while valid construct and language elements make it clear and user-friendly for students. Prior research highlights that valid test instruments are key to accurately reflecting students' competencies (Sukmawati & Irwandi, 2020).

2. Practicality of the Problem-Based Physics Teaching Module

The practicality test was conducted to gather direct feedback from students and teachers regarding the ease of using the problem-based physics teaching module to enhance SPS and learning outcomes. Practicality here refers to how easily the module can be implemented in the classroom. Feedback was collected via questionnaires distributed after the teaching process.

a. Student Responses

Students provided feedback based on their experiences using the problem-based physics teaching module. The module is designed to promote SPS and improve learning outcomes. Their responses indicate the extent to which the module supports these goals during instruction.

The analysis of student responses across three aspects—learning activities, the student worksheet, and learning materials—shows a very high level of practicality. Learning materials received the highest score (97.41%), highlighting their effectiveness in stimulating motivation and supporting SPS. Indicators such as promoting curiosity and supporting SPS scored as high as 98.89%. This aligns with Sukmawati & Irwandi (2020) and Arifin et al. (2024a), who note that well-designed, curiosity-driven materials can enhance scientific thinking and learning outcomes.

The learning activities component scored 96.11%, demonstrating that the instructional design effectively engages students. Motivation and problem-based activities both received perfect scores (100%), reflecting the strength of the PBL approach in fostering contextual learning experiences (Ayu et al., 2024). However, the indicator for group work scored slightly lower (91.11%), suggesting that collaborative elements could still be strengthened.

The student worksheet component scored 95.66% for practicality. The most highly rated indicators were the worksheet's attractiveness (100%) and its support for hands-on experimentation (96.67%) and tool use (97.78%). According to Rohmah et al. (2021) and Arifin (2024b), engaging student worksheet can help students grasp concepts through experimental activities. However, the clarity of the instructional steps scored somewhat lower (91.11%), indicating a need to refine this aspect.

Overall, the student feedback aligns with existing research on the value of PBL modules in promoting SPS and learning outcomes. In physics topics such as static fluids, this approach helps bridge theoretical understanding and practical application. Some areas, such as enhancing collaboration and improving instructional clarity in the student worksheet, can be further refined to better support the Merdeka Curriculum's vision of adaptive, contextual, and empowering learning.

b. Teacher Responses

Teachers also rated the practicality of the module highly across most aspects. The average practicality score for the initial activities was 89.33%, with elements such as teaching models and methods scoring 100%, while the flow of learning objectives was slightly lower at 80%. This suggests that the preparation phase is strong overall, though further work on clarifying learning goals would be beneficial.

The teaching module itself scored an average of 90.95%, with high marks for alignment with PBL stages and time allocation. The success of the module depends largely on the relevance of materials to real-life contexts, which enhances understanding and engagement (Maulida, 2022; Arifin, 2023; Arifin et al., 2024c). Collaborative learning strategies further confirm that PBL is effective for fostering both SPS and learning outcomes.

Learning materials earned an excellent score of 95.24%. Visually appealing content connected to everyday life was particularly well-received, and factors such as time management and the availability of resources were also key contributors to success.

The student worksheet received a practicality score of 93.33%, reflecting its strong support for collaborative, SPS-focused learning. However, some aspects—such as the alignment of experiments with learning objectives—scored slightly lower (86.67%). This suggests that further adaptation of experimental components could help optimize the PBL experience (Ayu et al., 2024).

Assessment tools also scored very highly, with 93.33% for SPS instruments and 95.56% for learning outcomes tests. These tools were praised for their clarity and appropriateness in measuring competencies and providing useful feedback for students' cognitive and scientific development. The practical design of the learning materials and assessments confirms their suitability for supporting PBL in the classroom.

c. Effectiveness of the Problem-Based Physics Teaching Module in Enhancing SPS

Science Process Skills (SPS) were measured using questionnaires administered before (pre-test) and after (post-test) instruction. The results show improvements across all SPS indicators. Pre-test scores ranged from 44.44% to 51.39%, reflecting relatively low initial skills. Post-test scores improved substantially, ranging from 72.22% to 88.19%. The highest post-test scores were in observation (88.19%) and experimentation (86.11%), while prediction showed the smallest gain (72.22%). Overall, all SPS indicators improved.

For observation skills, scores rose from 48.61% to 88.19%, indicating that students became more structured observers after instruction. Hidayati (2020) found that experimental activities within PBL encourage active fact-gathering and observation skills. Communication skills improved from 48.61% to 84.03%, demonstrating that PBL fosters students' ability to organize and present findings effectively (Susanti & Wahyuni, 2020).

Prediction skills showed the smallest gain (51.39% to 72.22%), suggesting that more targeted practice may be needed to develop this ability. Fitriani et al. (2019) recommend using challenging learning scenarios that require students to make data-based predictions.

For designing experiments, scores rose from 44.44% to 81.94%, highlighting how PBL supports students' ability to plan solutions and experiments. Project-based learning has been shown to enhance these skills (Suyadi & Hartati, 2021). Inference skills increased from 50.00% to 81.25%, demonstrating improved ability to draw conclusions from data (Suryani et al., 2020).

The indicator of identifying variables increased from 47.22% to 82.64%. This shows that students were able to identify variables better after being involved in problem-based learning. According to Putri et al. (2018), this process is very important to support the steps of experimentation and scientific analysis. The indicator of formulating hypotheses increased from 49.31% to 80.56%. This process requires a deep understanding of concepts and data, which is facilitated by the problem-based learning (PBL) approach. Wahyuni and Purwanto (2021) noted that problem-based learning helps students in formulating hypotheses through a problem-solving approach.

The indicator of data interpretation increased from 46.53% to 83.33%. This increase shows the success of PBL in training students to analyze and understand data more effectively. Research by Prasetyo & Nurhadi (2020) shows that data interpretation develops through learning based on real-case analysis. The indicator of experimenting showed an increase from 45.14% to 86.11%. Experimental activities implemented in problem-based learning provide students with opportunities to learn through direct practice. According to research by Santoso & Kurniawan (2019), experiments allow students to practice scientific skills comprehensively, thereby resulting in a significant increase in learning.

Problem-based learning has proven capable of improving all indicators of students' science process skills (SPS). The significant increase in indicators with a high level of complexity, such as experimenting and designing, demonstrates the effectiveness of PBL in developing in-depth science process skills. Meanwhile, indicators such as prediction, which showed lower improvement, require special attention with more targeted learning strategies.

The improvement of science process skills was also analyzed using the N-gain test, which can provide a general overview of the improvement in SPS scores between before and after the implementation of the Problem-Based Physics Teaching Module. The improvement in scores was obtained through the difference between pre-test and post-test scores, normalized with the maximum score difference and the pre-test score obtained by students. The results showed that the N-gain value obtained was 0.65, which falls into the moderate category, indicating an improvement in students' science process skills after the implementation of the problem-based physics teaching module. In addition, the interpretation of effectiveness based on N-gain standards reached 65.71%, which is classified as fairly effective. This indicates that the Problem-Based Physics Teaching

Module used was able to positively influence the development of students' SPS, although there is still room for further improvement to achieve even more optimal effectiveness.

The results of the N-gain analysis of science process skills scores for each indicator showed varied results. The indicator with the highest N-gain score was Observing (0.77) and Experimenting (0.75), both of which are in the high category and are interpreted as effective and fairly effective. Most of the other indicators, such as communicating, designing, inferring, identifying variables, formulating hypotheses, and interpreting data, had N-gain scores in the moderate category, with fairly effective effectiveness. However, the Prediction indicator recorded an N-gain score of 0.43, which is in the moderate category but is interpreted as less effective. These results indicate that learning successfully improved SPS in most indicators, although the Prediction indicator requires more attention to further enhance learning effectiveness.

CONCLUSION

Drawing upon the research objectives, findings, and discussion, this study concludes that the developed Problem-Based Physics Teaching Module is highly valid and thus well-suited for use in Physics instruction. The module also demonstrated a high level of practicality, as evidenced by positive responses from both teachers and students regarding its ease of implementation and integration into classroom learning. Furthermore, the module proved to be moderately effective in enhancing students' science process skills. These results suggest that integrating problem-based learning approaches into Physics education not only supports the achievement of learning objectives but also fosters the development of critical scientific competencies among students. Future refinements to the module, particularly in addressing areas of relatively lower improvement, could further optimize its impact on learning outcomes.

ACKNOWLEDGMENT

The researcher would like to express sincere gratitude to all parties who have contributed to this study. Special thanks are extended to the school, the Physics teacher, and the students of one of the schools in Pringgabaya District for their willingness to participate as subjects in this research.

REFERENCES

Arifin, A. A., Ramdani, A., & Andayani, Y. (2024a). Development of Learning Tools Based on the Culturally Responsive Transformative Teaching Model with a Socio-Scientific Issues Approach: Evaluation of Validity and Practicality. *Jurnal Penelitian Pendidikan IPA*, *10*(11), 9141-9155. https://doi.org/10.29303/jppipa.v10i11.9188

Aiken, L.R. (1997). Psychological testing and assessment 9 th edition. USA: Allyn and Bacon.

Arifin, A. A., Ramdani, A., Andayani, Y., & Hariadi, I. (2024b). Pengembangan E-Modul Ekosistem Berbasis Model Culturally Responsive Transformative Teaching dengan Pendekatan Socio-Scientific Issues Berbantuan Software 3D Pageflip Frofessional. *Journal of Classroom Action Research*, *6*(3), 673-685. https://doi.org/10.29303/jcar.v6i3.9035

Arifin, A. A. (2024c). Development of Mini Virtual Aquatic Ecosystem Learning Media Assisted by Professional 3D Pageflip Software. *International Journal of Science Education and Science*, *1*(2), 45-51.

https://doi.org/10.56566/ijses.v1i2.227

Ayu, H. D., Kurniawati, M. P., Purwanti, P. F., Lukitawanti, S. D., & Huda, M. N. (2024). Problem-based learning (PBL) solusi Efektif Meningkatkan Pemahaman Konsep Peserta Didik: Systematic Literature Review. *Pedagogy: Jurnal Ilmiah Ilmu Pendidikan*, *11*(2), 12-35.

Arifin, A. A., Doyan, A., Mahrus, M., Susilawati, S., Andayani, Y., & Muntari, M. (2023). PjBL Learning Training Based on Science Practicum Tools DNA and RNA Structures at the Attohiriyah Alfadiliyah Islamic Boarding School. *Unram Journal of Community Service*, *4*(2), 37-43. https://doi.org/10.29303/ujcs.v4i2.453

Dwiyanti, F. R., & Rosana, D. (2020). Analisis hasil belajar kognitif peserta didik menggunakan model problem based learning (PBM) pada pembelajaran IPA di sekolah dasar. *Jurnal Pendidikan: Teori, Penelitian, dan Pengembangan*, *5*(11), 1541–1548.

Dzikro, A. Z. T., & Dwiningsih, K. (2021). Kelayakan media pembelajaran berbasis laboratorium virtual pada sub materi kimia unsur periode ketiga. *Chemistry Education Practice*, *4*(2), 160-170. https://doi.org/10.29303/cep.v4i2.2389

Fitriyani, F., & Suparwoto, S. (2021). Pengembangan Modul ajar Model Online Project Based Learning (e-PjBL) untuk Meningkatkan Hasil Belajar Kognitif Ditinjau dari Kreativitas dan Kemampuan Awal Peserta Didik. *Jurnal Pendidikan Fisika*, *8*(1).

Flake, J. K., Pek, J., & Hehman, E. (2017). Construct validation in social and personality research: Current practice and recommendations. *Social Psychological and Personality Science*, *8*(4), 370-378. https://doi.org/10.1177/1948550617693063

Fauziah, F. M. (2022). Systematic Literature Review: Bagaimanakah Pembelajaran IPA Berbasis Keterampilan Proses Sains yang Efektif Meningkatkan Keterampilan Berpikir Kritis?. *Jurnal Pendidikan Mipa*, *12*(3), 455-463.

Fitriani, S., Sari, D. K., & Mukminin, A. (2019). Implementasi pendekatan pembelajaran berbasis masalah untuk meningkatkan keterampilan berpikir kritis siswa. *Jurnal Pendidikan Sains Indonesia, 7*(1), 35-45.

Hidayati, N. (2020). *Penerapan Pembelajaran Berbasis Masalah untuk Meningkatkan Kemampuan Analisis Siswa pada Matematika*. *Jurnal Pendidikan Sains Indonesia*, 8(2), 144-153. https://doi.org/10.17509/jpsi.v8i2.24688

Hake, R. R. (1998). Analyzing change/gain score. Indiana: Indiana University

Hidayat, A. (2023). Pembelajaran berbasis masalah untuk meningkatkan kemampuan berpikir kritis dan hasil belajar matematika siswa. *Jurnal Pendidikan Matematika*, *11*(1), 1–12.

Maulida, U. (2022). Pengembangan modul ajar berbasis kurikulum merdeka. *Tarbawi*, *5*(2), 130-138.

Maylitha, E., Alfiyana, F. M., Iskandar, M. F., Nurdiansyah, M. F., Hanifa, S., & Prihantini, P. (2023). Kesiapan Pendidik dan Tenaga Kependidikan dalam Mengimplementasikan Kurikulum Merdeka. *Indo-MathEdu Intellectuals Journal*, 4(3), 2523-2548.

Marisa, U., Yulianti, Y., & Hakim, A. R. (2020). Pengembangan e-modul berbasis karakter peduli lingkungan di masa pandemi COVID-19. In *Prosiding Seminar Nasional PGSD UNIKAMA*, 4(1), pp. 323-330.

Nengsih, N. R., Yusmaita, E., & Gazali, F. (2019). Evaluasi validitas konten dan konstruk bahan ajar asam basa berbasis REACT. *EduKimia*, *1*(1), 1-10. https://doi.org/10.24036/ekj.v1i1.104017

Penyangga, l., & student, b. L. M. T. O. I. (2022). Pengembangan modul ajar yang menerapkan model problem based learning untuk meningkatkan pemahaman konsep dan keterampilan proses sains peserta didik pada materi. *Jurnal biofiskim: issn*, *2684*, 995x.

Permendikbud. (2020). *Peraturan Menteri Pendidikan dan Kebudayaan Nomor 3 Tahun 2020 tentang Standar Nasional Pendidikan Tinggi*. Kemendikbud.

Putri, V. R. (2024). Pengaruh Model Pembelajaran Problem Based Learning Berbantuan Live Worksheet Terhadap Keterampilan Proses Sains Dan Hasil Belajar Peserta Didik Pada Materi Sistem Eksresi (Studi Ekperimen Kelas Xi Mipa Sma Negeri 1 Manonjaya Tahun Ajaran 2023/2024) *(Doctoral dissertation, Universitas Siliwangi).*

Paat, M., Kawuwung, F. R., & Mokalu, Y. B. (2021). Penerapan LKS model pembelajaran berbasis masalah untuk meningkatkan kemampuan berpikir tingkat tinggi SMPN 5 Tondano. *JISIP (Jurnal Ilmu Sosial dan Pendidikan)*, *5*(2).

Purnama, W., & Wulandari, S. (2021). *Pengaruh Pembelajaran Kontekstual terhadap Kemampuan Siswa dalam Menerapkan Konsep pada Kehidupan Sehari-hari*. *Jurnal Pendidikan IPA Indonesia*, 10(3), 401-410. https://doi.org/10.15294/jpii.v10i3.29043

Putri, R. A., Munandar, D., & Suryadi, D. (2018). Pengembangan kemampuan identifikasi variabel melalui pembelajaran berbasis masalah. *Jurnal Pendidikan IPA Indonesia, 5*(4), 101-110.

Prasetyo, D., & Sari, D. (2021). *Pembelajaran Berbasis Masalah dalam Meningkatkan Keterampilan Evaluasi Siswa pada Mata Pelajaran Fisika*. *Jurnal Pendidikan Fisika Indonesia*, 17(1), 25-35. https://doi.org/10.15294/jpfi.v17i1.2351

Prasetyo, D., & Nurhadi, S. (2020). Pengaruh pembelajaran berbasis kasus terhadap keterampilan interpretasi data siswa. *Jurnal Pendidikan dan Kebudayaan, 15*(2), 72-82.

Rohmah, A., Wisanti, W., & Putri, E. K. (2021). Kelayakan LKPD lumut berbasis discovery learning untuk melatihkan keterampilan literasi sains. *Berkala Ilmiah Pendidikan Biologi (BioEdu)*, *10*(1), 140-149. https://doi.org/10.26740/bioedu.v10n1.p140-149

Ramadani, M., Supahar, S., & Rosana, D. (2017). Validity of evaluation instrument on the implementation of performance assessment to measure science process skills. *Jurnal Inovasi Pendidikan IPA*, *3*(2), 180-188.

Rahman, A. (2022). Project Based Learning sebagai Upaya Meningkatkan Hasil Belajar dan Keterampilan Proses Sains Peserta Didik. Penerbit NEM.

Rizaldi, R., & Syahwin, S. (2023). Validitas E-Modul Praktikum Fisika SMA Berbasis Model Pembelajaran Problem Based Learning (PBL) terhadap Keterampilan Proses Sains Siswa SMA. *Jurnal Pendidikan Mipa*, 13(2), 322-328.

Sari, D. P. (2021). Analisis Penggunaan Media Pembelajaran dalam Pembelajaran Fisika di SMA Negeri 1 Yogyakarta. *Jurnal Pendidikan Fisika*, 9(2), 115-128.

Susanti, R. (2023). Analisis Kemampuan Guru dalam Memberikan Umpan Balik Konstruktif dalam Pembelajaran Fisika di SMP Negeri 3 Bandung. *Jurnal Penelitian Pendidikan Fisika*, 11(1), 55-68.

Sukmawati, D., & Irwandi, A. (2020). Development and Validation of Assessment Instruments for Learning Outcomes. *Journal of Educational Measurement and Evaluation*, 9(2), 112-125. https://doi.org/10.1016/j.jedu.2020.05.006

Salsabilla, I. I., Jannah, E., & Juanda, J. (2023). Analisis modul ajar berbasis kurikulum merdeka. *Jurnal Literasi Dan Pembelajaran Indonesia*, *3*(1), 33-41.

Suyadi, S., & Hartati, S. (2021). Model pembelajaran berbasis proyek untuk meningkatkan kemampuan merancang pada pelajaran sains. *Jurnal Pendidikan Dasar, 9*(2), 89-97.

Susanti, N., & Wahyuni, E. (2020). Efektivitas diskusi kelompok dalam pembelajaran berbasis masalah terhadap kemampuan komunikasi siswa. *Jurnal Pendidikan Biologi, 12*(1), 23-31.

Suryani, N., Hermawan, R., & Kusuma, D. (2020). Peningkatan kemampuan inferensi melalui pendekatan problem-based learning. *Jurnal Pendidikan dan Pembelajaran, 17*(2), 56-65.

Santoso, T., & Kurniawan, A. (2019). Pengaruh eksperimen dalam pembelajaran berbasis proyek terhadap keterampilan proses sains siswa. *Jurnal Pendidikan Fisika Indonesia, 8*(1), 45-52.

Taufik, M., & Doyan, A. (2022). Pengembangan media pembelajaran fisika berbasis google sites untuk meningkatkan kemampuan penguasaan konsep dan berpikir kritis peserta didik SMA. *Jurnal Ilmiah Profesi Pendidikan*, 7(3), 1167-1173. https://doi.org/10.29303/jipp.v7i3.743

Triwiyanto, T. (2021). Pengantar pendidikan. Bumi Aksara.

Wati, D. S. S., Aziz, A., & Fitri, A. Z. (2023). Kebijakan kurikulum merdeka belajar di perguruan tinggi. *Journal of Education Research*, 4(3), 1021-1030.