

Integrating Scientific Reading-based Authentic Assessment into Problem-based Learning to Enhance Students' Physics Problem-solving Skills

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Abstract

Developing students' ability to solve physics problems remains a major challenge because many learners tend to focus on mathematical procedures while experiencing difficulties in interpreting scientific information, constructing solution strategies and evaluating their reasoning processes. This study investigated the effectiveness of integrating Scientific Reading-Based Authentic Assessment (AA-SR) into Problem-Based Learning (PBL) to enhance students' physics problem-solving skills. A quasi-experimental study with a pretest-posttest control group design was conducted involving 57 tenth-grade students at an Islamic senior high school in Indonesia. The experimental group ($n = 30$) experienced PBL integrated with AA-SR through Scientific Reading Task, Authentic Task and Reflection and Feedback activities, while the control group ($n = 27$) received conventional PBL instruction. Data were collected using an essay-based physics problem-solving test assessing four indicators: understanding problems, planning solutions, carrying out solutions and evaluating results. The findings revealed that students who learned through AA-SR-integrated PBL achieved significantly higher problem-solving performance than those in the control group ($p < 0.001$). The greatest improvement was observed in understanding problems and planning solutions, indicating that scientific reading and authentic assessment activities supported students in developing accurate problem representations and systematic reasoning strategies. However, evaluation remained the most challenging aspect, highlighting the need for continuous reflective practice. These findings suggest that AA-SR provides an integrated instructional-assessment framework that enhances students' cognitive and metacognitive processes in physics problem solving.

Keywords: Authentic Assessment, Metacognitive Skills, Problem-based Learning, Scientific Literacy, Scientific Reasoning.

Introduction

Physics education in the twenty-first century is expected to develop students' ability to think critically, reason scientifically and solve complex problems rather than merely memorize concepts and formulas. Problem-solving skills are considered fundamental competencies in physics learning because they involve the ability to understand phenomena, construct appropriate representations, select relevant principles, apply scientific reasoning and evaluate the validity of solutions. Effective physics problem-solving requires an integration of conceptual understanding, analytical thinking and metacognitive regulation, allowing students to connect theoretical knowledge with real-world contexts. Therefore, modern science instruction needs to provide learning experiences that actively engage students in interpreting information, developing

solution strategies and reflecting on their thinking processes (1–3). However, actual classroom practices indicate that developing students' physics problem-solving skills remains challenging. Many students are still able to perform mathematical calculations but experience difficulties in understanding problem situations, identifying relevant variables, explaining scientific relationships and evaluating whether their solutions are reasonable. Students frequently focus on obtaining final numerical answers without demonstrating systematic reasoning or conceptual justification. Similar challenges have been reported in previous studies, showing that learners often experience obstacles in translating contextual problems into scientific representations and tend to use formula-based strategies without deeper conceptual understanding (4–7). These problems

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indicate the need for instructional strategies that support not only procedural competence but also the complete process of scientific problem solving. Although various instructional approaches have been introduced to improve students' problem-solving skills, several limitations remain. Problem-Based Learning (PBL) has been widely recognized as an effective approach for encouraging active learning and contextual problem solving; however, students may still struggle during the problem analysis and reflection stages when adequate scaffolding is not provided. Similarly, authentic assessment encourages students to engage with meaningful tasks, but its implementation often focuses primarily on performance evaluation rather than supporting the learning process itself. Scientific reading strategies have also been shown to enhance students' ability to interpret scientific information, yet they are rarely integrated systematically into assessment activities. Therefore, previous research has generally examined PBL, authentic assessment and scientific reading separately, leaving a gap regarding how these components can be integrated into a coherent instructional-assessment framework that supports all stages of problem solving (6, 8).

Several studies have provided important foundations for addressing this issue. Research on PBL has demonstrated positive effects on students' conceptual understanding, reasoning ability and higher-order thinking skills when students actively construct knowledge through meaningful problems (9, 10). Studies on authentic assessment have shown that contextual and performance-based assessment can improve knowledge transfer, engagement and students' ability to apply concepts in realistic situations (11, 12). Meanwhile, research on scientific reading and science literacy emphasizes that students' ability to analyze scientific texts and extract relevant information plays an important role in constructing accurate problem representations (13, 14). Nevertheless, limited studies have explored the integration of these three components as a unified model for improving physics problem-solving skills.

To address this limitation, the present study proposes the integration of Scientific Reading-Based Authentic Assessment (AA-SR) into Problem-Based Learning. AA-SR is conceptualized as an instructional-assessment framework consisting of the Scientific Reading Task (SRT),

Authentic Task (AT) and Reflection and Feedback (RF). Scientific Reading Task assists students in identifying information and developing an understanding of the problem; the Authentic Task provides opportunities to apply physics concepts in meaningful contexts; and Reflection and Feedback encourage students to evaluate their reasoning and improve their solutions. Unlike conventional assessment practices that mainly measure learning outcomes, AA-SR positions assessment as an integral part of the learning process that continuously supports students' cognitive and metacognitive development.

Based on the identified research gap, this study aims to investigate the effectiveness of integrating AA-SR into PBL in enhancing students' physics problem-solving skills. Specifically, this study addresses the following research questions:

- (a) Does the implementation of AA-SR integrated into PBL significantly improve students' physics problem-solving skills compared with conventional PBL?
- (b) Which indicators of problem-solving skills show the greatest improvement after the implementation of AA-SR? and
- (c) How do the components of AA-SR contribute to students' problem-solving processes?

It was hypothesized that students who learn through AA-SR integrated into PBL would achieve significantly higher problem-solving performance because the integration of scientific reading, authentic tasks and reflective feedback provides structured support throughout the problem-solving process.

Methodology

His study was designed to evaluate the effectiveness of Scientific Reading-Based Authentic Assessment (AA-SR) integrated into Problem-Based Learning (PBL) in enhancing students' physics problem-solving skills (15, 16). Problem-based learning has been shown to have a positive effect on students' motivation and physics problem-solving skills (17), while authentic assessment approaches grounded in scientific literacy and reading have been demonstrated to support students' scientific cognition (15). A quantitative research approach was employed to examine the impact of the intervention by comparing students' performance before and after the learning process, consistent with quasi-

experimental pretest-posttest designs commonly used to evaluate PBL-based interventions (18). The methodology was structured to ensure systematic implementation, including research design selection, participant criteria, learning intervention procedures, implementation consistency, instrument development and statistical analysis. These methodological procedures were established to provide valid evidence regarding the contribution of AA-SR in supporting students' cognitive and metacognitive processes during physics problem solving (18).

Research Design

This study employed a quasi-experimental design with a pretest-posttest control group approach to examine the effectiveness of integrating Scientific Reading-Based Authentic Assessment (AA-SR) into

Problem-Based Learning (PBL) on students' physics problem-solving skills. A quasi-experimental design was selected because the study was conducted in an authentic classroom environment where random assignment of individual students was not practically possible. This design allows researchers to evaluate instructional interventions while maintaining the natural structure of existing classes (19).

The experimental group received PBL instruction integrated with AA-SR components, while the control group received conventional PBL without explicit integration of scientific reading-based assessment activities. Both groups completed a pretest before the intervention and a posttest after the intervention to measure changes in physics problem-solving performance. The research design structure is presented in Table 1.

Table 1: Quasi-Experimental Pretest-Posttest Control Group Design

Group	Pretest	Learning Intervention	Posttest
Experimental group	Problem-solving test	PBL integrated with AA-SR	Problem-solving test
Control group	Problem-solving test	Conventional PBL	Problem-solving test

As shown in Table 1, both groups followed the same testing procedures, while the difference was located in the instructional treatment. This design enabled the comparison of learning outcomes between students experiencing AA-SR-based learning and those experiencing conventional PBL.

Participants and Research Setting

The participants consisted of 57 tenth-grade students from MAS Arrisalah Padang, Indonesia. The experimental group consisted of 30 students, while the control group consisted of 27 students. The selection of participants was conducted using purposive sampling based on the availability of comparable classes and similarity of academic characteristics before the intervention (20).

The inclusion criteria for participation were:

- (a) students enrolled in tenth-grade physics classes,
- (b) students who participated in all learning sessions and
- (c) students who completed both pretest and posttest assessments.

Students were excluded when they:

- (a) did not complete one of the assessment stages,
- (b) were absent during the intervention process, or
- (c) withdrew from participation.

To provide a clearer description of the research sample, the demographic characteristics of participants are presented in Table 2.

Table 2: Demographic Characteristics of Research Participants

Characteristics	Experimental Group (n = 30)	Control Group (n = 27)
Grade level	Grade X	Grade X
Mean age	15	15
Male students	30	27
Female students	0	0
School type	Islamic senior high school	Islamic senior high school
Physics topic	Newton's Laws	Newton's Laws
Characteristics	Experimental Group (n = 30)	Control Group (n = 27)

Table 2 indicates that both groups shared similar educational characteristics, including grade level, school context and physics learning content. This

similarity was considered important to minimize potential differences caused by participant characteristics rather than instructional intervention.

Learning Intervention and Implementation Fidelity

The intervention was conducted on Newton's Laws topics through structured learning sessions. The AA-SR framework consisted of three main components: Scientific Reading Task (SRT), Authentic Task (AT) and Reflection and Feedback

(RF). These components were embedded into the stages of PBL to support students' problem-solving processes from understanding problems to evaluating solutions (21).

The integration between AA-SR components, PBL stages and targeted problem-solving processes is presented in Table 3.

Table 3: Integration of AA-SR Components Within Problem-Based Learning

PBL Stage	AA-SR Component	Learning Activity	Problem-Solving Indicator
Problem orientation	Scientific Reading Task	Reading and identifying scientific information from contextual problems	Understanding the problem
Organizing learning activities	Scientific Reading Task	Determining relevant concepts and variables	Understanding and planning
Guiding investigation	Authentic Task	Applying physics concepts in authentic situations	Planning and carrying out solutions
Developing solutions	Authentic Task	Constructing explanations and solutions	Carrying out solutions
Evaluation	Reflection and Feedback	Reviewing reasoning and receiving feedback	Evaluating results

Table 3 illustrates that AA-SR was designed as an integrated instructional-assessment process rather than a separate evaluation activity. Each component provided specific support for different stages of students' problem-solving development. To ensure consistency of implementation, both experimental and control groups were taught by the same physics teacher. The teacher followed standardized lesson plans prepared before the intervention. An implementation observation checklist was used during each learning session to ensure that the AA-SR components were consistently applied in the experimental group and that both groups received comparable instructional duration and learning materials (22).

Research Instrument

Students' physics problem-solving skills were measured using an essay-based test developed based on problem-solving indicators adapted from Pólya's framework (23). Essay assessment was selected because it allows evaluation of students' reasoning processes rather than only final answers. The test focused on Newton's Laws and assessed four indicators: understanding the problem, planning the solution, carrying out the solution and evaluating the result.

Each item was assessed using an analytical scoring rubric. The operational definitions of problem-solving indicators are presented in Table 4.

Table 4: Operational Definitions of Physics Problem-Solving Indicators

Indicator	Description
Understanding the problem	Ability to identify known information, unknown variables and relevant concepts
Planning the solution	Ability to determine strategies and select appropriate physics principles
Carrying out the solution	Ability to apply concepts and complete problem-solving procedures accurately
Evaluating the result	Ability to verify answers and justify solution accuracy

Table 4 shows that the assessment focused on the complete problem-solving process, including cognitive and reflective aspects required in physics reasoning.

Data Analysis

The collected data were analyzed using descriptive and inferential statistics. Descriptive analysis included mean scores and standard deviations to

describe students' performance before and after the intervention. Learning improvement was analyzed using normalized gain (N-gain) to determine the magnitude of improvement in each problem-solving indicator. Before hypothesis testing, assumption tests were conducted, including normality and homogeneity analyses. An independent-samples t-test was used to compare posttest scores between the experimental and

control groups. This analysis was selected because preliminary pretest results indicated comparable initial abilities between groups, allowing post-intervention differences to be evaluated based on learning outcomes. Similar approaches have been applied in educational intervention studies involving equivalent pretest-posttest comparison groups (24). In addition, Cohen's *d* effect size was calculated to determine the practical significance of the AA-SR intervention. The analysis focused not only on overall scores but also on each problem-solving indicator to identify which aspects benefited most from the intervention.

Results

The results section presents the empirical evidence regarding the effectiveness of Scientific Reading-Based Authentic Assessment (AA-SR) integrated into Problem-Based Learning (PBL) in

improving students' physics problem-solving skills. The analysis focuses on students' initial abilities before intervention, differences in learning outcomes after intervention, improvement across problem-solving indicators and changes in students' written reasoning processes.

Initial Students' Problem-Solving Ability Before Intervention

Before implementing the learning intervention, a pretest was administered to both experimental and control groups to examine students' initial physics problem-solving abilities. This analysis was important to ensure that both groups had comparable baseline abilities before receiving different instructional treatments. The comparison of pretest scores between the experimental and control groups is presented in Table 5.

Table 5: Pretest Comparison of Students' Physics Problem-Solving Skills Before Intervention

Group	N	Mean	Standard Deviation	Category
Experimental Group	30	57.08	4.55	Low
Control Group	27	51.34	4.88	Low

Note: N= Number of Participants

The results presented in Table 5 indicate that both groups demonstrated relatively similar initial problem-solving abilities before the intervention. Students in both groups experienced difficulties in interpreting physics problems, determining appropriate solution strategies and evaluating their answers. These findings suggest that the experimental and control groups started from comparable learning conditions, allowing further analysis of the instructional effect of AA-SR integration.

Effect of AA-SR on Students' Physics Problem-Solving Performance

After the intervention, differences in students' problem-solving performance were observed between the experimental and control groups. The posttest results were analyzed based on four problem-solving indicators: understanding the problem, planning the solution, carrying out the solution and evaluating the result. The comparison of posttest performance between the two groups is presented in Table 6.

Table 6: Comparison of Posttest Scores Across Problem-Solving Indicators

Indicator	Experimental Group (M ± SD)	Control Group (M ± SD)
Understanding the Problem	90.63 ± 4.82	61.84 ± 6.25
Planning the Solution	87.66 ± 4.63	58.82 ± 6.01
Carrying Out the Solution	88.73 ± 4.56	59.63 ± 6.12
Evaluation	71.83 ± 4.61	52.46 ± 6.28
Overall Score	84.71 ± 4.66	58.19 ± 6.17

The results in Table 6 demonstrate that students who learned through AA-SR integrated with PBL achieved higher scores across all problem-solving indicators compared with students who experienced conventional PBL. The most noticeable improvement occurred in the understanding and planning indicators, suggesting that the Scientific Reading Task component helped

students analyze problem situations and organize relevant information before attempting mathematical solutions.

To provide a clearer visualization of students' performance differences across problem-solving indicators, the comparison between the experimental and control groups is presented in Figure 1.

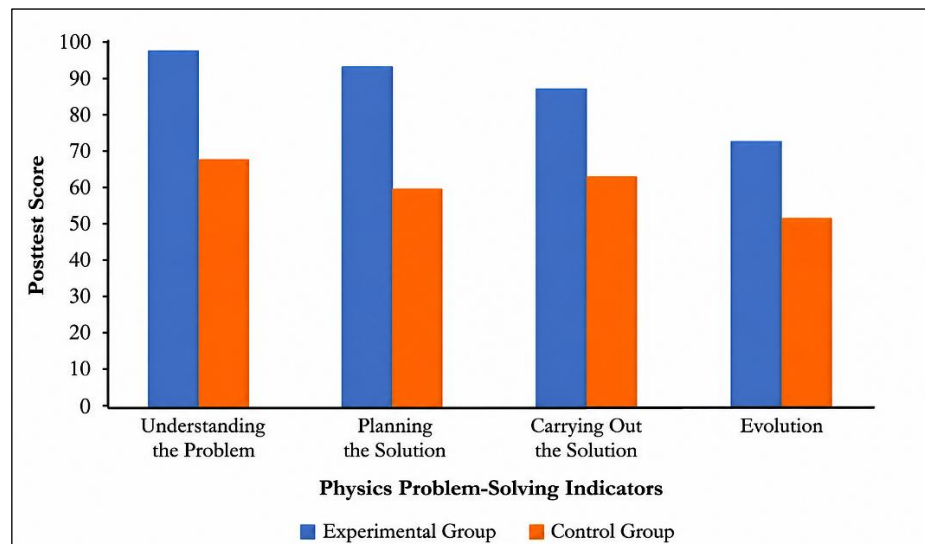


Figure 1: Comparison of Posttest Scores Across Physics Problem-solving Indicators Between Experimental and Control Groups

Figure 1 shows that the experimental group consistently outperformed the control group in all indicators. The difference was particularly evident in the early stages of problem solving, where students were required to understand information and develop solution strategies. This finding indicates that AA-SR supports not only final performance but also the thinking processes required to solve physics problems systematically.

Statistical Effect of AA-SR Implementation

To determine whether the observed difference between groups was statistically significant, an independent-samples t-test was conducted. The statistical comparison of students' posttest scores is presented in Table 7.

Table 7: Independent-samples T-test Results for Students' Problem-solving Performance

Variable	Experimental Group (M ± SD)	Control Group (M ± SD)	t-test	df	p-value	Cohen's d
Problem-solving skills	84.71 ± 4.66	58.19 ± 6.17	18.42	55	<0.001	4.88

Note: df = Degree of Freedom

As shown in Table 7, the independent-samples t-test revealed a significant difference between the experimental and control groups. The results indicate that students who experienced AA-SR integrated into PBL achieved significantly higher physics problem-solving performance. Furthermore, the effect size analysis showed a very large effect (Cohen's $d = 4.88$), suggesting that the integration of scientific reading, authentic tasks and reflective feedback provided substantial

support for students' problem-solving development.

Improvement of Problem-solving Indicators Based on N-Gain Analysis

In addition to comparing final achievement scores, N-gain analysis was conducted to assess the magnitude of improvement for each problem-solving indicator. The comparison of students' improvement between the experimental and control groups is presented in Table 8.

Table 8: Comparison of N-Gain Scores Across Problem-solving Indicators

Indicator	Experimental Group	Category	Control Group	Category
Understanding the Problem	0.86	High	0.11	Low
Planning the Solution	0.79	High	0.07	Low
Carrying Out the Solution	0.61	Moderate	0.11	Low
Evaluation	0.44	Moderate	0.23	Low

The results presented in Table 8 show that the AA-SR intervention produced greater improvement across all problem-solving indicators. The greatest improvement occurred in understanding the problem, indicating that scientific reading activities effectively supported students in

identifying information, interpreting contexts and recognizing relevant physics principles.

The comparison of N-gain scores between experimental and control groups is illustrated in Figure 2.

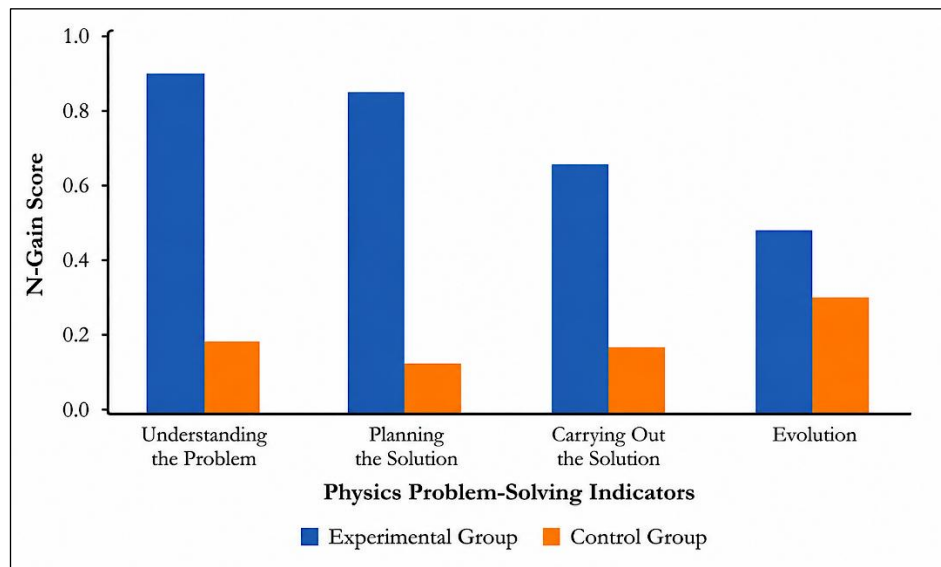


Figure 2: Comparison of N-Gain Scores Between Experimental and Control Groups Across Problem-solving Indicators

Figure 2 confirms that AA-SR produced stronger learning improvement than conventional PBL. The integration of the Scientific Reading Task and the Authentic Task particularly enhanced students' ability to understand and plan solutions. However, the evaluation indicator showed relatively lower improvement, suggesting that developing reflective and metacognitive skills requires continuous practice and longer learning experiences.

Analysis of Students' Problem-solving Responses

To obtain deeper insight into how AA-SR influenced students' reasoning processes, students' written responses before and after the intervention were analyzed. The comparison of students' problem-solving characteristics is presented in Table 9.

Table 9: Comparison of Students' Written Responses Before and After AA-SR Implementation

Indicator	Before AA-SR	After AA-SR
Understanding	Limited identification of information	Complete identification of variables and concepts
Planning	Unclear strategy selection	Structured solution planning
Execution	Formula-based calculation without explanation	Concept-based and systematic calculation
Evaluation	Minimal verification	Logical justification and reflection

The qualitative evidence presented in Table 9 supports the quantitative findings by showing improvements in students' reasoning processes. Before AA-SR implementation, students tended to focus directly on calculations without analyzing the problem context. After participating in AA-SR-based learning, students demonstrated more

structured reasoning by identifying relevant information, selecting appropriate concepts, explaining solution steps and evaluating their answers. Overall, these findings demonstrate that AA-SR integrated into PBL improves physics problem-solving skills by strengthening both cognitive processes, such as understanding and

applying concepts and metacognitive processes, such as monitoring and evaluating solutions.

Discussion

The findings of this study demonstrate that integrating Scientific Reading-Based Authentic Assessment (AA-SR) into Problem-Based Learning (PBL) significantly improves students' physics problem-solving skills compared with conventional PBL. These results answer the first research question by confirming that students who experienced AA-SR showed higher performance because the learning process provided structured support from understanding problems to evaluating solutions. The effectiveness of this approach can be explained by the alignment between problem-oriented learning activities and assessment processes that continuously guide students' reasoning. Previous studies have emphasized that successful physics problem solving depends not only on conceptual knowledge but also on students' ability to construct representations, select appropriate strategies and monitor their thinking processes (2). Therefore, embedding assessment within learning activities allows students to receive continuous support during each stage of problem solving rather than only receiving evaluation after learning has ended. The improvement found in the experimental group indicates that AA-SR strengthens the implementation of PBL by addressing several challenges commonly found in problem-based environments. Although PBL encourages inquiry and active knowledge construction, students may experience difficulties when they are required to solve complex problems without sufficient scaffolding. The integration of the Scientific Reading Task, the Authentic Task and Reflection and Feedback provides a systematic pathway that helps students analyze information, apply concepts and evaluate their solutions. This finding extends previous research showing that PBL becomes more effective when supported by structured guidance that helps students organize knowledge and regulate their learning processes (1, 9). Thus, AA-SR contributes by transforming assessment from a separate measurement activity into an active component of the learning process.

The second research question focused on identifying which problem-solving indicators showed the greatest improvement after AA-SR

implementation. The results showed that the greatest improvement occurred in the understanding-the-problem indicator. This finding suggests that the Scientific Reading Task component successfully helped students interpret problem contexts, recognize important information and connect scientific concepts before attempting calculations. In physics learning, difficulties often emerge because students fail to develop accurate problem representations rather than because they lack mathematical ability. Scientific reading activities encourage learners to slow down the problem-solving process, analyze information critically and construct meaningful relationships between concepts and evidence. This interpretation is consistent with previous studies indicating that scientific literacy and reading-based strategies improve students' ability to comprehend scientific information and develop stronger conceptual representations (13, 14).

The improvement in planning and carrying out solutions further indicates that Authentic Task plays an important role in bridging conceptual understanding and practical application. Through authentic activities, students are encouraged to apply Newtonian concepts in meaningful situations instead of memorizing equations without understanding their relevance. This process supports the development of strategic thinking because students must determine appropriate principles, organize solution steps and justify their reasoning. Previous studies have shown that authentic assessment promotes deeper learning by connecting classroom knowledge with real-world contexts and encouraging students to demonstrate higher-order thinking skills (11, 12). Therefore, the combination of authentic assessment and PBL provides students with opportunities to transform theoretical knowledge into applicable problem-solving strategies.

Although all indicators improved after the intervention, the evaluation indicator remained the most challenging aspect for students. This result supports the initial hypothesis that evaluation and reflective reasoning require longer learning experiences because they involve metacognitive processes such as monitoring, checking and judging the quality of one's own thinking. Students may successfully understand concepts and perform calculations, but still struggle to critically evaluate whether their

answers are scientifically reasonable. Previous research has shown that self-evaluation and metacognitive regulation develop gradually through repeated feedback opportunities and explicit reflective practices (25, 26). Therefore, although the Reflection and Feedback component of AA-SR contributed positively, longer implementation periods may be required to maximize students' evaluative abilities.

Regarding the third research question, the findings reveal that AA-SR contributes to students' problem-solving processes by creating an integrated learning cycle consisting of interpretation, application and reflection. The Scientific Reading Task helps students construct initial understanding, the Authentic Task supports the application of knowledge and Reflection and Feedback encourage students to reconsider and improve their solutions. This integrated mechanism represents the main theoretical contribution of the study because previous research has commonly investigated scientific reading, authentic assessment and PBL separately. By combining these components, AA-SR provides a more comprehensive framework that supports both cognitive and metacognitive dimensions of problem solving. This perspective aligns with current developments in assessment research, emphasizing that assessment should support learning development rather than merely measure final achievement (2, 3, 27).

From a practical perspective, the AA-SR framework offers an alternative instructional approach for physics teachers who aim to develop students' reasoning abilities. The findings suggest that students need structured opportunities to read scientific problems, engage with authentic contexts and reflect on their thinking processes. However, several limitations should be acknowledged. The study involved 57 students from a specific educational setting, which may limit the generalizability of the findings to broader populations. In addition, the intervention was conducted within a limited period; therefore, future research should involve larger and more diverse samples, longer implementation periods and different physics topics to examine the consistency of AA-SR effectiveness. Future studies may also explore the integration of AA-SR with digital learning environments to support adaptive

feedback and students' independent learning processes (9, 28–30).

Conclusion

This study investigated the effectiveness of integrating Scientific Reading-Based Authentic Assessment (AA-SR) into Problem-Based Learning (PBL) to enhance students' physics problem-solving skills. The findings provide empirical evidence that students who learned through AA-SR-integrated PBL achieved significantly better problem-solving performance than students who experienced conventional PBL. These results confirm that the integration of scientific reading activities, authentic learning tasks and reflective feedback provides meaningful support for students throughout the problem-solving process, from understanding scientific information to evaluating the validity of their solutions. The results further demonstrate that AA-SR produced different levels of improvement across problem-solving indicators. The greatest improvement was found in understanding the problem, indicating that the Scientific Reading Task effectively supported students in identifying relevant information, interpreting problem contexts and constructing accurate conceptual representations. Improvements were also observed in planning and carrying out solutions, suggesting that Authentic Task activities helped students transform conceptual understanding into systematic problem-solving strategies. However, evaluation remained the most challenging indicator, showing that reflective and metacognitive abilities require continuous practice and longer learning experiences.

The main contribution of this study lies in the conceptualization and empirical examination of AA-SR as an integrated instructional-assessment framework within PBL. Unlike conventional approaches that separate learning activities and assessment practices, AA-SR positions assessment as an active component of learning that facilitates cognitive processing, application of knowledge and reflective thinking. Therefore, this study expands existing perspectives on assessment-based learning by demonstrating how scientific reading, authentic assessment and feedback mechanisms can be combined to strengthen physics problem-solving skills. From a practical perspective, the AA-SR framework provides an alternative strategy for

physics teachers to design learning environments that emphasize reasoning processes rather than only final answers. Teachers can integrate structured scientific reading activities, contextual problem tasks and reflective feedback to help students develop deeper conceptual understanding and more systematic approaches to solving physics problems.

Despite these contributions, several limitations should be acknowledged. The study involved a relatively limited number of participants from a specific educational context, which may influence the generalizability of the findings. Furthermore, the intervention was conducted within a limited instructional period, which may not fully capture the long-term development of students' reflective and evaluative abilities. Future research is recommended to examine the effectiveness of AA-SR with larger and more diverse student populations, different educational levels and various physics topics. Longitudinal studies are also needed to explore how continuous exposure to AA-SR influences students' metacognitive development and long-term problem-solving performance. Further investigations integrating AA-SR with digital learning technologies may provide additional insights into adaptive and personalized approaches for supporting science learning.

Abbreviations

AA-SR: Scientific Reading-based Authentic Assessment, AT: Authentic Task, PBL: Problem-Based Learning, RF: Reflection and Feedback, SRT: Scientific Reading Task.

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Author Contributions

Zaturrahmi: Conceptualization, Methodology, Investigation, Data Curation, Formal Analysis, Visualization, Writing Original Draft Preparation, Review, Editing, Festiyed: Supervision, Conceptualization, Validation, Methodology, Critical Review, Yohandri: Methodology, Validation, Formal Analysis, Manuscript Review, Ratnawulan: Investigation, Instrument Validation, Supervision, Manuscript Review, Fatni Mufit: Conceptualization, Validation, Supervision, Writing – Review, Editing. All authors have read and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

Conflict of Interest

The authors declare that there are no financial, professional, or personal conflicts of interest that could have influenced the work reported in this manuscript.

Data Availability

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request. Supporting research materials, including the assessment instruments and implementation documents, may also be provided for academic purposes, subject to institutional regulations.

Declaration of Artificial Intelligence (AI) Assistance

During the preparation of this manuscript, the authors used generative artificial intelligence (AI)-assisted tools solely to improve the clarity, grammar and academic readability of the manuscript. The AI tools were not used to generate research ideas, collect or analyze data, interpret findings, or formulate scientific conclusions. All intellectual content, data interpretation and final editorial decisions remain the sole responsibility of the authors, who carefully reviewed and verified the entire manuscript before submission.

Ethics Approval

This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki for research involving human participants. Before the commencement of the study, permission to conduct the research was

obtained from the school administration of MAS Arrisalah Padang. Since the participants were under 18 years of age, written informed consent was obtained from their parents or legal guardians before data collection. Students participated voluntarily and were informed that their responses would remain confidential and would be used exclusively for research purposes. All collected data were anonymized to protect participants' privacy.

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References

1. Tawfik AA. Essential Readings in Problem-Based Learning: Exploring and Extending the Legacy of Howard S. Barrows. *Interdiscip. J Probl Learn*. 2015;9(2). doi: 10.7771/1541-5015.1593
2. Panadero E, Lipnevich AA. A review of feedback models and typologies: Towards an integrative model of feedback elements. *Educ Res Rev*. 2022;35(1):100416. doi: 10.1016/j.edurev.2021.100416
3. Mu L, Cole J. Behavior-based student typology: A view from student transition from high school to college. *Res High Educ*. 2019;60(8):1171-1194. doi:10.1007/s11162-019-09547-x.
4. Yerushalmi H. Creative solutions and development for social workers treating people with serious mental illness - contributions from supervision. *J Soc Work Pract*. 2017;31(3):293-306. doi: 10.1080/02650533.2016.1253004
5. Mirzaei A, Chen Z, Haghighat F, Yerushalmi L. Removal of pharmaceuticals from water by homo/heterogeneous Fenton-type processes - a review. *Chemosphere*. 2017;174:665-88. doi: 10.1016/j.chemosphere.2017.02.019
6. Walsh D, McCartney G, Smith M, Armour G. Relationship between childhood socioeconomic position and adverse childhood experiences (ACEs): a systematic review. *J Epidemiol Community Health*. 2019;73(12):1087-93. doi: 10.1136/jech-2019-212738
7. Docktor JL, Dornfeld J, Frodermann E, Heller K, Hsu L, Jackson KA, Mason A, Ryan QX, Yang J. Assessing student written problem solutions: a problem-solving rubric with application to introductory physics. *Phys Rev Phys Educ Res*. 2016;12(1):010130. doi: 10.1103/PhysRevPhysEducRes.12.010130
8. Kaushik V, Walsh CA. Pragmatism as a research paradigm and its implications for social work research. *Soc Sci*. 2019;8(9):255. doi: 10.3390/socsci8090255
9. Chen O, Woolcott G, Sweller J. Using cognitive load theory to structure computer-based learning including MOOCs. *J Comput Assist Learn*. 2017;33(4):293-305. doi: 10.1111/jcal.12188
10. Loyens SMM, Jones SH, Mikkers J, van Gog T. Problem-based learning as a facilitator of conceptual change. *Learn Instr*. 2015;38:34-42. doi: 10.1016/j.learninstruc.2015.03.002
11. Sokhanvar Z, Salehi K, Sokhanvar F. Advantages of authentic assessment for improving the learning experience and employability skills of higher education students: a systematic literature review. *Stud Educ Eval*. 2021;70:101030. doi: 10.1016/j.stueduc.2021.101030
12. Villarroel V, Bloxham S, Bruna D, Bruna C, Herrera-Seda C. Authentic assessment: creating a blueprint for course design. *Assess Eval High Educ*. 2018;43(5):840-54. doi: 10.1080/02602938.2017.1412396
13. Cervetti GN, Pearson PD, Palincsar AS, Afflerbach P, Kendeou P, Biancarosa G, Higgs J, Fitzgerald MS, Berman AI. How the Reading for Understanding Initiative's research complicates the simple view of reading invoked in the science of reading. *Read Res Q*. 2020;55(S1):S161-72. doi: 10.1002/rrq.343
14. Fang W, Wang C, Liu Z, Wang L, Liu L, Li H, Xu S, Zheng A, Qin X, Liu L, Xiao FS. Physical mixing of a catalyst and a hydrophobic polymer promotes CO hydrogenation through dehydration. *Science*. 2022;377(6604):406-10. doi: 10.1126/science.abo0356
15. Chang S-N, Chiu M-H. The development of authentic assessments to investigate ninth graders' scientific literacy: in the case of scientific cognition concerning the concepts of chemistry and physics. *Int J Sci Math Educ*. 2005;3(1):117-40. doi: 10.1007/s10763-004-5239-0
16. Prahani BK, Rizki IA, Nisa' K, Citra NF, Alhusni HZ, Wibowo FC. Implementation of online problem-based learning assisted by digital book with 3D animations to improve student's physics problem-solving skills in magnetic field subject. *J Technol Sci Educ*. 2022;12(2):379. doi: 10.3926/jotse.1590
17. Argaw AS, Haile BB, Ayalew BT, Kuma SG. The effect of problem-based learning (PBL) instruction on students' motivation and problem-solving skills of physics. *Eurasia J Math Sci Technol Educ*. 2017;13(3):857-71. doi: 10.12973/eurasia.2017.00647a
18. Mohamed SA, Elazim Ibrahim SA, Abdelaalem MM, Mohamed Eldiasty NE. Effect of problem-based learning approach program on meta-cognitive thinking skills and cooperative learning attitude among nursing students: quasi experimental study. *BMC Nurs*. 2025;24(1):899. doi: 10.1186/s12912-025-03485-z
19. Miller EC, Severance S, Krajcik J. Motivating teaching, sustaining change in practice: design principles for teacher learning in project-based learning contexts. *J Sci Teacher Educ*. 2021;32(7):757-79. doi: 10.1080/1046560X.2020.1864099
20. Memon MA, Thurasamy R, Ting H, Cheah J-H. Purposive sampling: a review and guidelines for quantitative research. *J Appl Struct Equ Model*. 2024;9(1):1-23. doi: 10.47263/JASEM.9(1)01
21. Nicholas G, Muwonge CM, Joseph N. The role of problem-based learning approach in teaching and

- learning physics: a systematic literature review. *F1000Research*. 2023;12:951. doi: 10.12688/f1000research.136339.2
22. Nelson MC, Cordray DS, Hulleman CS, Darrow CL, Sommer EC. A procedure for assessing intervention fidelity in experiments testing educational and behavioral interventions. *J Behav Health Serv Res*. 2012;39(4):374-96. doi: 10.1007/s111414-012-9295-x
 23. Chacón-Castro M, Buele J, López-Rueda AD, Jadán-Guerrero J. Pólya's methodology for strengthening problem-solving skills in differential equations: a case study in Colombia. *Computers*. 2023;12(11):239. doi: 10.3390/computers12110239
 24. Lakens D. Calculating and reporting effect sizes to facilitate cumulative science: a practical primer for t-tests and ANOVAs. *Front Psychol*. 2013;4:62627. doi: 10.3389/fpsyg.2013.00863
 25. Andrade HL. A critical review of research on student self-assessment. *Front Educ*. 2019;4:468374. doi: 10.3389/educ.2019.00087
 26. Yan Z, Brown GTL. A cyclical self-assessment process: towards a model of how students engage in self-assessment. *Assess Eval High Educ*. 2017;42(8):1247-62. doi: 10.1080/02602938.2016.1260091
 27. Boud D, Soler R. Sustainable assessment revisited. *Assess Eval High Educ*. 2016;41(3):400-13. doi: 10.1080/02602938.2015.1018133
 28. Ismail RN, Yerizon, Fauzan A. Exploring self-regulated learning and their impact on students' mathematical communication skills on the topic of number patterns with the blended learning system. *J High Educ Theory Pract*. 2023;23(16). doi: 10.33423/jhetp.v23i16.6477
 29. Feng K, Zhao Y, Liu Y, Yang T, Zhao C, Sous J, Cohan A. Physics: benchmarking foundation models on university-level physics problem solving. In: *Findings of the Association for Computational Linguistics: ACL 2025*. Stroudsburg (PA): Association for Computational Linguistics; 2025. p. 11717-43. doi: 10.18653/v1/2025.findings-acl.610
 30. Zhai X, Chu X, Chai CS, Jong MSY, Istenič Starčič A, Spector MD, Liu JB, Yuan J, Li Y. A review of artificial intelligence (AI) in education from 2010 to 2020. *Complexity*. 2021;1-18. doi:10.1155/2021/8812542

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