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Profile of the Problem-Based Learning Model Assisted by ELTRA to Strengthen Students' Problem-Solving Skills in Support of SDG 4: Quality Education

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ABSTRACT
Objective: *This study aims to analysed senior high school students' physics problem-solving skills on the topic of Light Waves as a basis for implementing a Problem-Based Learning (PBL) model assisted by a digital book (ELTRA) in supporting SDG 4: Quality Education.* ***Method:*** *The research employed a qualitative descriptive design using a preliminary survey approach. Data were collected through problem-based essay tests, student response questionnaires, and teacher interviews. The participants were 104 eleventh-grade students from three science classes at MAN 2 Gresik. Students' test results were analysed using qualitative descriptive analysis based on five indicators of problem-solving skills: visualizing the problem, describing physics concepts, planning solutions, executing plans, and evaluating results.* ***Results:*** *The findings revealed that most students demonstrated low problem-solving skills. A total of 102 students were categorized at a low level (scores 0–40), only two students reached the moderate category (scores 41–70), and none achieved a high level (scores 71–100). These results indicate that students experience difficulties in applying structured problem-solving steps, particularly in planning and executing solutions.* ***Novelty:*** *This study provides an empirical problem-solving profile as a foundational need analysis for developing a PBL model integrated with an ELTRA digital book, specifically designed to support structured physics problem-solving skills and align physics learning innovation with the objectives of SDG 4.*

INTRODUCTION

Education in the 21st century encourages students to master higher order thinking skills, including critical, creative, collaborative, and communicative thinking, as well as problem-solving skills. These skills play a crucial role in addressing increasingly complex global challenges, such as technological advancements, social dynamics, and rapid environmental change (Miterianifa et al., 2021). Problem-solving skills are one of the key competencies that students must master in order to adapt and think critically in response to various emerging challenges (Berkat et al., 2025; Fadzil, 2024). In education, the development of problem-solving skills is not only aimed at academic achievement but also serves as preparation for future generations who must be able to face real-world problems, both within local and global communities (Majir et al., 2021; Yayat et al., 2022; Bates et al., 2022). Problem solving is a fundamental component of 21st-century education; through continuous practice in addressing complex problems, students become more adaptive, creative, and capable of making well-considered decisions when encountering real-life situations beyond the classroom (Asri et al., 2024; Manurung et al., 2022; Jaganathan et al., 2024). Therefore, the role of schools and teaching practices is crucial in facilitating learning experiences that allow students to practice systematic thinking, problem formulation, and solution development. Awareness of the importance of problem solving in modern education has encouraged many educational institutions to adopt active and project- or problem-based learning models, such as Problem Based Learning (PBL), so that students do not merely become passive recipients of information but take a central role in the learning process (Wijaya et al., 2024).

To overcome this problem, one of the most effective models used is Problem Based Learning (PBL), this model is designed to encourage students to learn through a structured problem-solving process (Ummah et al., 2023; Nicholus et al., 2023; Rakhmawati, 2021). The PBL model directly addresses low problem-solving skills by presenting complex problems as learning triggers (Houghton, 2023). When students are confronted with a problem, they are required to identify objectives, formulate hypotheses, design investigative steps, and determine solutions based on scientific evidence. This process habituates students to engage in logical and reflective reasoning, allowing problem-solving skills to develop naturally th..rough meaningful learning experiences (Khairani & Arsyad, 2024; Pozuelo-Muñoz et al., 2023). PBL also provides opportunities for students to collaborate and engage in discussions within small groups. Such group discussions facilitate the exchange of ideas, clarification of concepts, and evaluation of arguments, all of which contribute to improving the quality of problem-solving strategies. In PBL implementation, where teachers act as facilitators rather than sole sources of information, students gain greater opportunities to explore learning materials independently and take responsibility for their own learning processes. This approach is particularly necessary in physics education, which requires mastery of abstract concepts and scientific inquiry skills (Wibowo et al., 2024). Through the stages of PBL, from problem orientation to reflection, students become accustomed to modeling, quantitative analysis, and data-driven decision-making, all of which are essential for solving physics problems (Worachak et al., 2023).

Physics learning requires instructional models that can foster scientific thinking processes and problem-solving abilities, as physics emphasizes conceptual understanding, relationships among variables, and the application of scientific principles to real-world phenomena (Widiarini et al. 2025). Physics concepts are generally abstract, such as light waves, electromagnetism, and mechanics, and therefore require learning approaches that connect these concepts to concrete phenomena through exploration and inquiry activities. According to Kinasih et al., (2023) conceptual physics learning requires strategies that encourage students to analyze phenomena scientifically rather than merely memorizing formulas. Consequently, the Problem Based Learning (PBL) model is one of the most suitable approaches to meet these needs (Kinasih., 2023). PBL provides a problem-based learning environment that stimulates students' cognitive engagement through stages of problem identification, hypothesis formulation, data collection, information analysis, and conclusion drawing (Hidayat et al., 2023). This process aligns with the stages of scientific reasoning in physics and is highly effective in enhancing problem-solving skills. Physics learning demands that students solve problems through systematic analysis, and PBL has been proven to significantly improve this ability, as it does not merely present knowledge but places students directly in situations that require the application of concepts (Nicholus et al., 2023; Hidayatullah et al., 2021).

The implementation of PBL can help students build more meaningful conceptual understanding. In physics learning, students often experience misconceptions due to limited involvement in the knowledge construction process. PBL reduces this issue by providing opportunities for students to discover concepts through investigative activities. As explained by Ningsih et al. (2023), problem-based learning enables students to understand the relationship between abstract concepts and real phenomena, thereby improving the quality of understanding and long-term retention. The PBL model also emphasizes student-centered learning and the development of 21st-century competencies, including creativity, critical thinking, collaboration, and problem-solving skills (Prahani et al., 2022). Thus, PBL is not only theoretically relevant but also aligned with current Indonesian education policies. Overall, physics learning requires the PBL model because it provides a learning environment that stimulates scientific reasoning, enhances problem-solving skills, strengthens conceptual understanding, improves social interaction, and supports the implementation of modern curricula. These advantages make PBL an ideal approach to help students understand physics concepts while preparing them to face the challenges of 21st-century life (Amin et al., 2021).

Despite its advantages, the PBL model has several limitations in classroom practice, such as the need for longer instructional time, students' low learning independence, limited learning resources to support scientific inquiry, and challenges faced by teachers in designing problems that match students' ability levels (Safitri et al., 2022). To overcome these limitations, the integration of interactive digital technology is an important solution to strengthen PBL implementation in classrooms (Simanjuntak et al., 2021). One increasingly used technology is interactive e-books, which can integrate text, images, videos, simulations, and problem-solving-based activities within a single digital learning platform (Firdaus & Pahlevi, 2022). Interactive e-books provide systematic and easily accessible learning resources, helping students conduct independent exploration in accordance with PBL stages without fully relying on teachers (Saputri et al., 2023). Features such as animations of physical phenomena, optical concept simulations, interactive modules, and reflective quizzes enable students to understand abstract concepts more concretely and visually, thereby reducing confusion when dealing with complex problems (Ningsih et al., 2023). In addition, the presentation of context-based problems in e-books can guide students more effectively in identifying problems, formulating hypotheses, and evaluating solutions independently, thus supporting the flow of scientific inquiry in PBL (Firdaus & Pahlevi, 2022). Recent studies indicate that integrating e-books into PBL significantly increases students' learning motivation and engagement, while also improving problem-solving skills through more interactive and contextual learning experiences (Qotrunnada et al., 2023). To address this gap, the present study aims to analyze the problem-solving profile of senior high school students on the topic of light waves as a basis for developing a PBL model supported by ELTRA in the Light Waves material.

RESEARCH METHOD

This study employed a qualitative descriptive research design. This design was selected because the purpose of the study was not to test hypotheses but to explore, describe, and interpret students' problem-solving profiles based on authentic learning conditions. A qualitative descriptive approach allows the researcher to present factual, in-depth descriptions of students' abilities as reflected in their responses to tests, questionnaires, and interviews. This design is also appropriate for obtaining rich and contextual information regarding students' cognitive processes, learning experiences, and challenges in understanding light-wave concepts.

Research Site and Participants

The research was conducted at MAN 2 Gresik, which consists of three grade XI science classes. A total of 104 students participated in the study. The sampling technique used was total population sampling, considering that all students in the target group were included to obtain a comprehensive profile of problem-solving skills. The inclusion criteriawere: 1.) students enrolled in the physics subject on the topic of light waves; 2.) students who completed all research instruments (test, questionnaire, and interview). No exclusion criteria were applied because the study aimed to capture the complete variation of students' abilities within the natural learning environment.

Research Instruments

Three types of instruments were used to collect data: 1.) Problem-based essay test, The essay test consisted of items constructed according to the five indicators of Heller's problem-solving model (Visualize the problem, Describe the physics, plan a solution, Execute the plan, and Check and evaluate the solution). The test items were developed based on real-world problems relevant to students' daily experiences; 2.) Student response questionnaire, the questionnaire collected data on students' perceptions of problem-solving difficulties, learning motivation, and learning atmosphere that may influence their problem-solving performance. The questionnaire consisted of closed and open-ended items to allow both quantitative trends and qualitative insights; 3.) Teacher interview guide**.** Semi-structured interviews were conducted with physics teachers to gain additional perspectives on students' learning characteristics, challenges encountered during light-wave lessons, and factors affecting students' problem-solving skills.

Validity

All instruments underwent expert validation. The essay test was reviewed by three expert validators in physics education. Revisions were made according to their comments related to content accuracy, clarity of questions, and alignment with problem-solving indicators.

Data Collection Procedure

Data were collected in three stages: 1.) Students completed the problem-based essay test; 2.) Students filled out the response questionnaire immediately afterward; 3.) Follow-up interviews were conducted with teachers to triangulate findings.

Data Analysis Technique

Data were analyzed using a qualitative descriptive analysis technique following three steps: 1.) Data reduction: selecting, categorizing, and coding students' answers based on the five problem-solving indicators; 2.) Data display: organizing findings in narrative, tabular, and diagrammatic forms to show patterns of student abilities; 2.) Conclusion drawing and verification: interpreting patterns, comparing them with theoretical frameworks, and triangulating data from tests, questionnaires, and interviews.

This analytical approach enables a comprehensive description of high school students' problem-solving abilities in physics, particularly in the light-wave topic, and provides empirical evidence for the development of a PBL-based e-book (ELTRA). The stages of the research carried out are presented in Figure 1.

Figure 1. Research Method

RESULTS AND DISCUSSION

Results

Physics Problem-Solving Skills Test

Each student's ability to solve physics problems varies, as each has their own strategy for finding solutions. In this study, students were given five questions about Light Waves to measure their problem-solving skills. In completing the questions, students were asked to follow the instructions and demonstrate four indicators of problem-solving skills, namely: 1.) Visualize the problem; 2.) Describe the problem in terms of physics concepts; 3.) Plan a solution; 4.) Execute the plan; and 5.) Check and evaluate. The results of the students' physics problem-solving skills were then obtained and presented in the following graph.

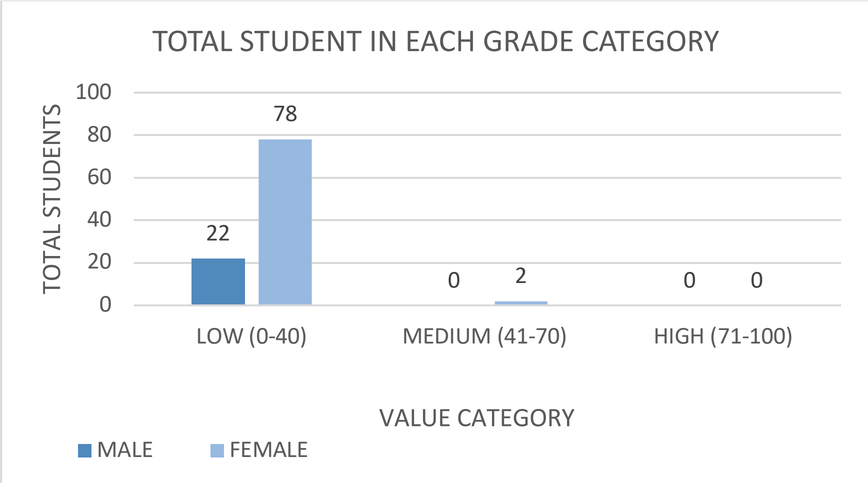

Figure 2. Relationship between value categories and number of students

Students who score between 0 and 40 are classified as low, while those who score between 41 and 70 are classified as medium, and those who score between 71 and 100 are classified as high. Each question has a total score of 20, with details of indicators visualize the problem (4 points), physics description (4 points), Plan a solution (4 points), Execute the plan (4 points), and Check and evaluate (4 points). Of the total 102 students at MAN 2 Gresik, most scored in the low category. This shows that students' ability to solve physics problems is still weak, and they are not yet able to solve problems well. However, there were 2 students who were in the medium category. Based on these findings, it appears that students still have difficulty solving physics problems, especially in the five indicators measured. To map the relationship between student ability (person) and the level of difficulty of the items or problem indicators, Rasch analysis in Winsteps was used as follows.

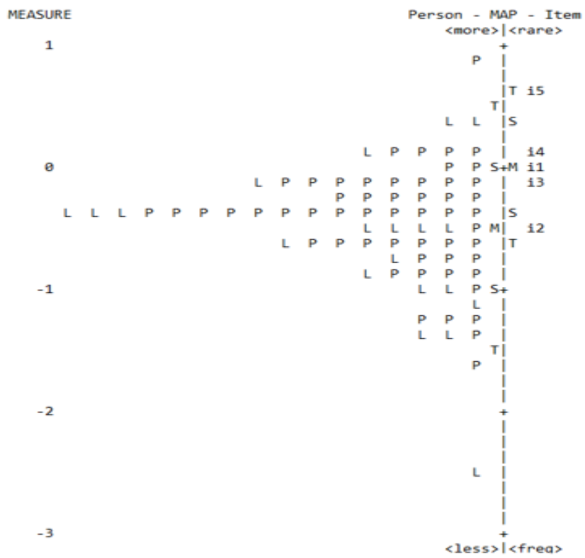

Figure 3. Distribution of student abilities and level of difficulty of test items

Left side = student ability (the higher, the better).
Right side = indicator difficulty (the higher, the more difficult).

Most students are around i2–i4, which means that the test difficulty level is quite appropriate for most students. Only a few students above i5 (the 5th indicator) are considered too difficult for most participants. Some students below i2 means that there are students with very low abilities. Female students (P) have higher abilities because some of them are above i5, while male students (L) are more spread out in the middle and bottom of the map, meaning they have lower abilities. The average results of student understanding on each problem-solving ability indicator are presented in the following section.

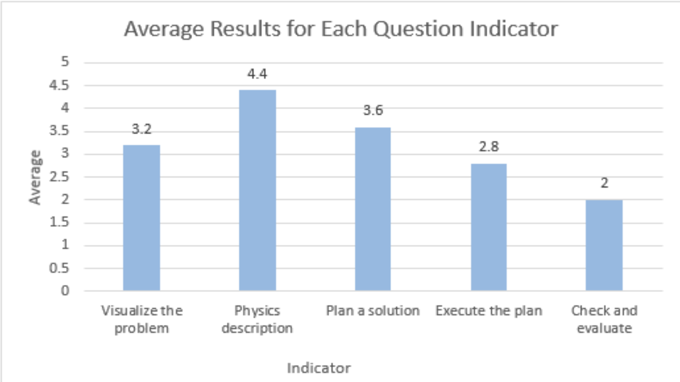

Figure 4. Average scores of students on each indicator

Figure 4 shows that students experienced more difficulties with indicators related to the implementation of problem-solving plans. Although students found it relatively easy to understand the physics problems given, they still faced obstacles in determining the right solution to solve them.

Visualizing Problem

In this indicator, students present explanations/sketches of physical phenomena correctly.

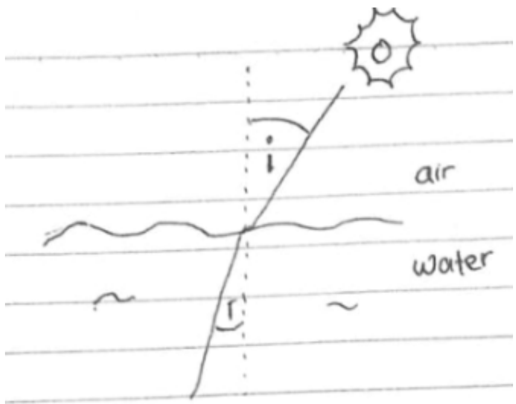

Figure 5. Visualizing Problem

Describe the Problem in Terms of Physics Concepts

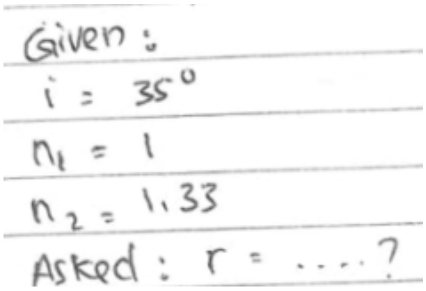

Figure 6. Problem in Terms of Physics Concepts

Plan the Solution

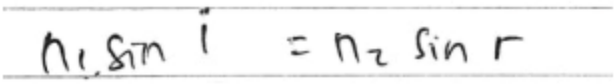

Figure 7. Plan the Solution

Using the Solution

In this indicator, students systematically apply principles into equations correctly and substitute the values of the variables into the physics equations correctly.

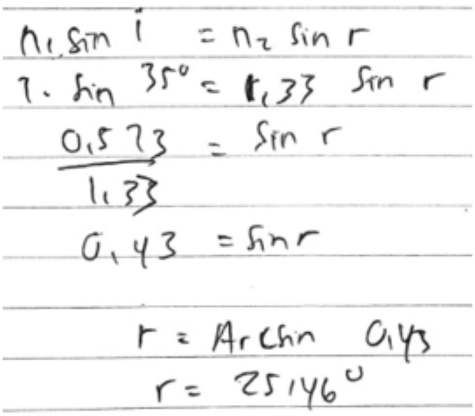

Figure 8. Using the Solution

Evaluating the Solution

In this indicator, students draw conclusions from the answers they have obtained.

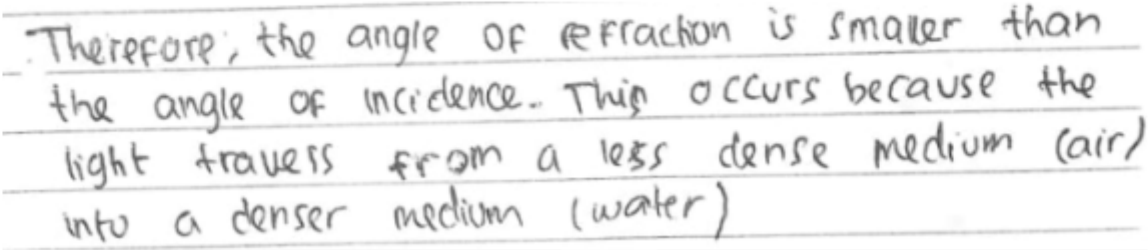

Figure 9. Evaluating the Solution

Discussion

Student Response Questionnaire Results

To determine students' responses in solving problems based on their problem-solving abilities, a questionnaire containing 10 statements about their physics learning experiences and responses to problem-solving questions was administered. Students were asked to choose one of four response scales: 1 (Strongly Disagree), 2 (Disagree), 3 (Agree), and 4 (Strongly Agree).

Table 1. Student Response Questionnaire Results

No	Statement	Percentage (%)			
		1	2	3	4
1	I often have trouble understanding what is being asked in physics questions.	1.9 (2)	26.9 (28)	51.0 (53)	20.2 (21)
2	I am having difficulty finding the important information needed to solve the problem in the physics question.	3.8 (4)	37.5 (39)	50.0 (52)	8.7 (9)
3	I often have difficulty determining the Appropriate physics concept to solve problems in physics questions.	3.8 (4)	26.9 (28)	60.6 (63)	8.7 (9)
4	I rarely understand the relationship between physical quantities to solve problems in physics questions.	1.9 (2)	37.5 (39)	53.8 (56)	6.7 (7)
5	I don't know the steps to take to solve physics problems.	7.7 (8)	54.8 (57)	34.6 (36)	2.9 (3)
6	I often choose formulas without understanding whether they are appropriate for the problem.	13.5 (14)	48.1 (50)	31.7 (33)	6.7 (7)
7	I often make mistakes in my calculations because I don't have a clear plan.	1.9 (2)	26.9 (28)	63.5 (66)	7.7 (8)
8	I was not thorough when applying the steps to solve physics problems.	4.8 (5)	36.5 (38)	53.8 (56)	4.8 (5)
9	I rarely double-check the calculations I have obtained.	16.3 (17)	51.9 (54)	30.8 (32)	1.0 (1)
10	I always feel uncertain when I get the answer to a physics problem.	5.8 (6)	16.3 (17)	60.6 (63)	17.3 (18)

Results of Teacher Interviews

In addition to the student response questionnaire, results were also obtained from interviews with physics teachers. Based on the results of interviews with physics teachers, it was found that in the learning process, teachers usually provide an introduction at the beginning so that students can better understand the direction of learning. This strategy shows a contextual approach, but its implementation still tends to be teacher centered. The teacher also said that he had applied the Problem-Based Learning (PBL) model, and the students' response to this model was quite positive because they became more active and enthusiastic in observing the problems given. However, in its implementation, obstacles were still encountered, such as students experiencing confusion in determining the appropriate formula or concept to solve physics problems. This shows that students' ability to connect theory with the application of concepts still needs to be improved.

Teachers believe that problem-solving skills are very important because they can help students understand physics concepts more deeply. In the learning process, students tend to analyze the information contained in the questions, but still have difficulty choosing the appropriate approach, which shows that students are still in the early stages of analytical thinking. Teachers also said that learning media such as LCDs and videos were quite helpful in the learning process, but their use was still passive. Therefore, more interactive media such as e-books were more effective in increasing student engagement. Teachers also revealed that they had used e-books due to the limited availability of printed books, and in their opinion, the use of e-books greatly helped students understand the material and solve physics problems. Overall, this interview shows that the application of the PBL model is still limited, students' problem-solving skills still need to be strengthened, and the use of digital media such as interactive e-books has great potential to support more meaningful and contextual physics learning.

Related research

This study aims to assess the effectiveness of implementing the Problem-Based Learning (PBL) model supported by digital books in improving high school students' physics problem-solving skills. An analysis of several previous studies published in national and international journals during the period 2020 to 2025 was then conducted. A summary of the results of previous studies is presented in the following table.

Table 2. Literature Review

No.	Author (Year)	Article Title	Research Method	Research Results
1	(Asiyah et al., 2021)	The Effect of Problem Based Learning (PBL) on Problem Solving Ability and Cognitive Learning Outcomes of Students of SMA Negeri 10, Bengkulu City	Quasi-Experiment	This study aims to determine the effect of the PBL model on problem-solving skills. The results show that the use of PBL in the experimental class significantly improved problem-solving skills.
2	(Dasusmi et al., 2024)	The Effectiveness of the Problem Based Learning (PBL) Model on the Mathematical Problem-Solving Ability of Grade IX Students	Quasi-Experiment	The results of this study indicate that the application of the PBL model is effective in improving mathematical problem-solving abilities.
3	(Sibarani et al., 2024)	The Effect of Problem Based Learning (PBL) Model Assisted by Learning Videos on Mathematical Problem Solving Ability	Quasi-Experiment	The results obtained indicate that learning with the PBL model assisted by learning videos has an effect on mathematical problem-solving skills.
4	(Susino et al., 2023)	The Influence of Problem Based Learning (PBL)	Quasi-Experiment	The Problem Based Learning (PBL) learning model has an influence on the mathematical

No.	Author (Year)	Article Title	Research Method	Research Results
		Learning Model on the Mathematical Problem-Solving Ability of Grade X High School Students		problem-solving abilities of class X students at SMA Negeri 1 Betung.
5	(Muslimin & Purwaningsih, 2023)	Meta-Analysis: The Effect of PBL-Based Student Worksheets on Critical Thinking and Problem-Solving Skills in Physics	Meta-Analysis	The use of Problem-Based Learning-based Student Worksheets (LKPD) can improve students' critical thinking and problem-solving skills in physics learning by 90%.
6	(Meylinda et al., 2024)	The Effect of Problem Based Learning (PBL) Model Assisted by Canva-Based Animation Media on Physics Learning Outcomes in High School	Quasi-Experiment	The effect of implementing the Problem Based Learning (PBL) model with the help of Canva-based animation media on physics learning outcomes in high schools is in the moderate category, as evidenced by an effect size value of 0.80.
7	(Hasugian & Wahyuni, 2025)	The Effect of Using Problem-Based Learning Physics Learning Modules on Problem Solving in Newton's Laws	Quasi-Experiment	This study aims to determine the effect of the Problem Based Learning (PBL) learning module on the physics problem-solving abilities of class X students on Newton's Laws at SMA Negeri 2 Tanjungbalai. Based on the results of data analysis, it shows that there is a significant influence of the problem-based learning model on the results of problem-solving abilities.
8	(Sinaga et al., 2025)	Efforts to Improve Students' Problem-Solving Skills through the Problem Based Learning Model on Measurement Material in Class X	Classroom action research	Problem-based learning allows students to be more active in finding solutions, discussing, and applying physics concepts to real-life situations. Furthermore, the PBL model also helps students improve their confidence and communication skills in conveying their ideas and arguments
9	(Indarti & Wiyatmo, 2025)	Development Of Stem-Based Pbl Lkpd Assisted by Phet Simulation To Improve Material Mastery And	Quasi-Experiment	This study aims to determine the effectiveness of STEM-based PBL LKPD assisted by PhET Simulation in improving mastery of the

No.	Author (Year)	Article Title	Research Method	Research Results
		Physics Solving Skills Of High School Students		material produced by STEM-based PBL LKPD assisted by PhET Simulation which is suitable for use in physics learning to improve mastery of the material and problem-solving skills in the material of elasticity and Hooke's law.
10	(Yusra et al., 2022)	Creating an E-LKPD Model of Problem Based Learning Integrated with Phet Simulation to Improve High School Students' Physics Problem-Solving Skills	Research and Development (R&D)	The E-LKPD product created has a very high level of feasibility and usability and can improve students' physics problem-solving skills

Based on Table 2, several articles show that the application of the PBL learning model by teachers has a very positive effect on improving students' problem-solving skills. The use of the learning model plays an important role in systematically improving problem-solving skills and has an impact on learning outcomes in physics.

CONCLUSION

Fundamental Finding: This study demonstrates that senior high school students' physics problem-solving skills on the topic of Light Waves are predominantly at a low level. Most students are not yet accustomed to applying systematic problem-solving steps, particularly in planning solutions, executing appropriate strategies, and evaluating results. These findings confirm the initial research problem and highlight the need for learning approaches that explicitly train structured problem-solving processes. **Implication:** The results imply that physics learning should not only focus on conceptual understanding but also emphasize the development of students' problem-solving skills through structured learning models. The integration of the Problem-Based Learning (PBL) model with the ELTRA digital book offers a promising instructional alternative by providing contextual problems, guided inquiry, and interactive digital support aligned with 21st-century learning and SDG 4: Quality Education. **Limitation:** This study is limited to a qualitative descriptive analysis conducted in a single school and focused on one physics topic, namely Light Waves. Therefore, the findings cannot be generalized to broader contexts without further investigation. **Future Research:** Future studies are recommended to develop and experimentally test the effectiveness of the PBL-ELTRA model on students' problem-solving skills across different physics topics and educational settings. Quantitative or mixed methods approaches involving larger samples are also suggested to strengthen the generalizability of the findings.

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