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Implementation of PBL by Applying TaRL on Vibration Material to Improve Learning Outcomes of Eighth Grade Students

Azizah Wahyuningsih[1*], Agung Mulyo Setiawan[2], Sitti Djuwarijah[3]

[1] Sekolah Pascasarjana, State University of Malang, Indonesia.
[2*] Pendidikan IPA, State University of Malang, Indonesia.
[3] SMPN 2 Pakis, Malang, Indonesia.
E-mail: agung.mulyo.fmipa@um.ac.id
*Corresponding Author

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ABSTRACT

Penelitian ini bertujuan untuk meningkatkan hasil belajar siswa kelas delapan tentang getaran dengan menggunakan model Pembelajaran Berbasis Masalah (PBL) yang dikombinasikan dengan pendekatan Pengajaran pada Tingkat yang Tepat (TaRL). Dilakukan di SMP Negeri 2 Pakis, penelitian ini menggunakan desain pre-test dan post-test satu kelompok. Siswa dikelompokkan ke dalam tingkat kemampuan berpikir rendah, menengah, dan tinggi berdasarkan tes diagnostik awal. Aktivitas pembelajaran disesuaikan dengan tingkat masing-masing kelompok, didukung oleh simulasi PhET interaktif untuk mengeksplorasi konsep getaran. Masalah kontekstual yang sesuai dengan kemampuan mereka membantu siswa memahami materi dengan lebih baik dan berpartisipasi aktif dalam pemecahan masalah. Hasil menunjukkan rata-rata n-gain sebesar 0,45, yang menunjukkan peningkatan sedang dalam hasil belajar. Selain peningkatan akademis, siswa juga meningkatkan kemampuan berpikir kritis, kolaborasi, dan motivasi mereka. Penelitian ini menunjukkan bahwa menggabungkan PBL dengan TaRL merupakan strategi yang efektif untuk meningkatkan pembelajaran dan keterlibatan dalam topik sains kelas delapan seperti getaran..

This study aimed to improve eighth-grade students' learning outcomes on vibrations by using the Problem-Based Learning (PBL) model combined with the Teaching at the Right Level (TaRL) approach. Conducted at SMP Negeri 2 Pakis, the research used a one-group pre test and post-test design. Students were grouped into low, medium, and high thinking ability levels based on an initial diagnostic test. Learning activities were tailored to each group's level, supported by interactive PhET simulations to explore vibration concepts. Contextual problems matched to their abilities helped students understand the material better and participate actively in problem-solving. The results showed an average n-gain of 0.45, indicating a medium improvement in learning outcomes. Besides academic gains, students also improved their critical thinking, collaboration, and motivation. This study suggests that combining PBL with TaRL is an effective strategy to enhance learning and engagement in eighth-grade science topics like vibrations.

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INTRODUCTION

Based on the initial observation conducted in grade VIII at SMP Negeri 2 Pakis, it was found that students' learning achievement in the topic of vibrations is still at a low level. Several factors suspected to be the causes include: (1) a learning approach that tends to be monotonous and lacks variation, dominated by lectures and assignments, (2) a lack of student interest in participating in learning due to activities that are not challenging enough, (3) low student engagement during the learning process, which ultimately (4) contributes to less than optimal learning outcomes. This condition is also observed at SMPN 7 Muaro Jambi. Research by Jufrida et al. (2020) shows that only about 60% of students

achieve the Minimum Completeness Criteria (KKM), so most students still require remedial programs.

To improve student learning outcomes, improvements in the implementation of learning are necessary, one of which is by applying a more relevant and effective learning model. The Ministry of Education and Culture recommends the use of Problem Based Learning (PBL) as one of the learning models that supports the development of 21st-century skills. PBL encourages students to formulate problems, think critically and analytically, collaborate in groups, and solve problems based on available information and data (Wijaya et al., 2018). Through this model, students are given the opportunity to explore the knowledge they already have and build new understanding, both of basic concepts and more complex ones.

The uniqueness of the PBL model lies in its student-centered approach based on contextual problems, thereby encouraging deeper understanding through triggering questions (Malmia, 2019). To support the effectiveness of its implementation, the Teaching at the Right Level (TaRL) approach is also used, which is a method that adjusts the learning process according to each student's thinking ability. Thus, students can be more active and optimally involved in the learning process (Santoso, 2024). In line with Indonesia's commitment to realizing equitable and improved quality education, the TaRL approach becomes one of the strategic solutions to address learning gaps, increase student participation, and ensure every individual has the opportunity to reach their best potential (Ismail, 2024).

A similar study was conducted by Indriyani et al. (2024) in the article titled "Improving Student Learning Outcomes on the Topic of Work and Energy Through the PBL Model in Grade VIII D at SMPN 34 Semarang." The results of the study showed a significant improvement in learning outcomes, increasing from 70.6% of students completing the material in cycle I to 85.3% in cycle II. The distinctive difference in this study compared to previous ones lies in the integration of interactive learning media in the form of PhET Simulation. The use of this interactive media is expected to increase students' interest and motivation to learn as well as reduce boredom during the learning process.

Through the use of PhET simulations in the classroom, students can engage in activities that resemble games but still support the development of courage and self confidence (Ozcan et al., 2020). According to Yulianti et al. (2018), learning that involves PhET simulations can sharpen students' problem-solving skills. These simulations have proven to be an effective medium to assist teachers in delivering science material using a problem-based approach, which simultaneously helps students build conceptual understanding and increase their engagement in the scientific process (Ben, 2022). Furthermore, the use of PhET as a discussion medium in the classroom can foster enthusiasm, interest, as well as feelings of enjoyment and challenge among students (Mallari, 2020).

Based on the previous explanation, this study was conducted with the aim of implementing the PBL learning model combined with the TaRL approach, supported by the interactive PhET media, on the topic of vibrations in grade VIII F at SMP Negeri 2 Pakis. The primary objective of this study is to improve students' cognitive learning outcomes. The research question addressed is: Does the implementation of the PBL learning model with the TaRL approach on the topic of vibrations improve the learning outcomes of students in grade VIII F at SMPN 2 Pakis? This problem arises from the low learning outcomes caused by the use of a learning method that tends to be monotonous and lacks active student involvement in the learning process. This study is limited to the application of the PBL model combined with the TaRL approach specifically in the science subject, especially on the topic of vibrations in grade VIII F at SMPN 2 Pakis. The main focus of the research is the improvement of students' cognitive learning outcomes, which are measured using an initial test (pre-test) and a final test (post-test). The assessment instruments were developed based on thinking indicators that align with the stages in the PBL model and are adjusted to the students' initial abilities as analyzed through the TaRL approach. Additionally, to increase student involvement during the learning process, this study also integrates the interactive PhET learning media as a supporting tool for learning activities.

METHOD

This study was conducted at SMP Negeri 2 Pakis in the 2024/2025 academic year. The approach used was descriptive quantitative with a pre-experimental research design, employing a one-group pre-test post-test design. The research subjects consisted of 28 students from grade VIII F who were selected as the sample. This study involved only one class as the experimental group, without a control class for comparison. The research process was carried out in one learning cycle consisting of two meetings, focusing on the topic of vibrations.

In the implementation of this study, treatment was given to students through the application of the PBL learning model combined with the TaRL approach. Before the learning activities began,

students were first given 10 cognitive diagnostic assessment questions to measure their initial knowledge. The results of this assessment were then used to group the students into three categories based on their thinking ability levels: high, medium, and low, in accordance with the basic principles of the TaRL approach. As explained by Mubarokah (2022), the TaRL approach emphasizes grouping students based on their thinking ability levels so that the learning process can be tailored to the needs of each group.

After students were grouped based on their thinking ability levels, they were given a pre-test designed to measure their initial learning outcomes. The questions were adjusted to the cognitive level of each group. Next, students participated in learning activities using the PBL model. The PBL model used refers to five main steps, namely: (1) inviting students to understand and engage with the problem, (2) organizing students in learning activities, (3) guiding the group investigation process, (4) facilitating the development and presentation of solution results, and (5) helping students analyze and evaluate the problem-solving process they have conducted (Hosnan, 2014).

At the orientation stage, students were given contextual problems through the Student Worksheet (Lembar Kerja Peserta Didik - LKPD) and asked to identify the problems contained within that context. Next, at the organization stage, students were divided into five groups based on the results of the diagnostic assessment: one group with a high thinking level (5 students), two groups with a medium thinking level (consisting of 5 and 6 students respectively), and two groups with a low thinking level (each consisting of 6 students). The LKPD used in the learning process was adjusted to the thinking ability level of each group to encourage active student involvement in the learning process.

At the investigation and presentation stage, students were asked to fill in data tables, answer questions in the LKPD, and conduct practical simulations using the interactive PhET application on their mobile phones. After these activities, each group presented their discussion results in front of the class. At the evaluation stage, the teacher and students together analyzed the learning outcomes and classified possible misconceptions that arose during the process.

After the entire learning sequence was completed, students were given a post-test whose content and structure were similar to the pre-test and adjusted to the thinking ability levels of each group. Research data were obtained from the results of the pre-test and post test, which consisted of multiple-choice questions, matching true-false statements, and essay questions. These three types of questions were designed to measure the improvement in cognitive learning outcomes according to the students' thinking ability levels. The following are the details of the cognitive levels present in the pre-test and post-test questions.

Table 1. Cognitive Levels of Pre-test and Post-Test Questions

Thinking Level	Question Numbers	Explanation
Low	1, 6, 8, 10	Understand (C2)
	2, 3, 5, 9	Apply (C3)
	4, 7	Analyze (C4)
Medium	1, 2, 8	Understand (C2)
	3, 4, 10	Apply (C3)
	5, 9	Analyze (C4)
	6, 7	Evaluate (C5)
High	8	Understand (C2)
	4, 9	Apply (C3)
	1, 2, 3, 5, 7	Analyze (C4)
	6, 10	Evaluate (C5)

According to Krathwohl and Anderson (2001), students' thinking abilities can be classified into two levels: Low Order Thinking Skills (LOTS) and Higher Order Thinking Skills (HOTS). LOTS includes cognitive abilities at the levels of remembering (C1), understanding (C2), and applying (C3). Meanwhile, HOTS covers advanced thinking skills such as analyzing (C4), evaluating (C5), and creating (C6). In this study, the construction of questions was adjusted to the categories of students' thinking abilities determined based on the results of the initial diagnostic assessment. For students in the low thinking group, the questions emphasized cognitive levels C2 and C3. For the medium group, the questions were designed as a combination of C2 and C3 (LOTS) as well as C4 and C5 (HOTS). For the high thinking group, the questions focused more on mastering analysis and evaluation skills, namely at cognitive levels C4 and C5.

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Data from the pre-test and post-test results obtained from the students were analyzed using the normalized gain (n-gain) method with the assistance of SPSS software. This analysis aimed to evaluate the effectiveness of implementing the PBL learning model combined with the TaRL approach in improving students' cognitive learning outcomes. The calculation of the n-gain score was carried out using the following formula.

$$N - Gain = \frac{\%Posttest - \%Pretest}{100 - \%Pretest}$$

After the n-gain values were obtained, the data were further analyzed by referring to the classification of learning improvement effectiveness proposed by Hake, as cited in Sunyono (2015).

Table 2. Criteria for N-Gain Scores

Score	Criteria
n-gain ≥ 0,7$	High
0,3 ≤ n-gain < 0,7$	Medium
n-gain < 0,3	Low

This classification is used to assess the extent of improvement in students' cognitive abilities after participating in learning based on the PBL model combined with the TaRL approach. Through this grouping, the researcher can evaluate the effectiveness level of the applied learning strategy and identify the extent of the learning's contribution to improving students' learning outcomes.

RESULT AND DISCUSSION

Based on initial observations of the eighth-grade students at SMP Negeri 2 Pakis, it was found that students' academic achievement, particularly in the science subject, was still relatively low. Several factors are suspected to be the main causes of this condition, including: (1) the use of monotonous and less varied teaching methods, which are still dominated by lectures and task assignments; (2) students' boredom due to unengaging learning activities; (3) low levels of active participation from students during the learning process; and (4) the overall impact of these factors is reflected in the generally low learning outcomes.

To address the issue of low student learning outcomes, efforts must be made to change the learning approach to one that is more effective and capable of increasing student engagement. One alternative solution that can be implemented is the integration of the Problem-Based Learning (PBL) model with the Teaching at the Right Level (TaRL) approach in the topic of Vibrations for class VIII F at SMP Negeri 2 Pakis. The implementation of the TaRL approach in learning involves several important stages, namely: (1) mapping students' learning needs, (2) designing and implementing instructional strategies suited to their level of ability, (3) reflecting on and evaluating the learning process, and (4) developing continuous improvement steps. According to Novena (2024), the TaRL approach has been proven effective in gradually and structurally improving students' thinking skills.

The initial step in the learning process is to map students' learning needs through a cognitive diagnostic assessment. This assessment is constructed in the form of ten multiple choice questions relevant to the topic of vibrations, with difficulty levels adjusted to identify students' initial thinking abilities. Based on the assessment results, scores ranged from 20 to 80. Students were then classified into three groups: low (scores 20–30), medium (scores 40– 50), and high (scores 60–80). A total of 12 students were categorized as low-level (Group A), 11 students as medium-level (Group B), and 5 students as high-level (Group C). This grouping served as the basis for the teacher to design instructional strategies tailored to each student's cognitive level.

The next stage involves designing and implementing differentiated lesson plans. At this stage, the teacher is responsible for systematically and structurally planning classroom learning activities (Astuti et al., 2020). In designing these activities, several key aspects must be considered, including the instructional methods to be employed, the learning resources, and the media that support the teaching and learning process. Equally important is the establishment of clear and measurable learning objectives (Ananda & Amiruddin, 2019). After mapping students' learning needs through diagnostic assessments, the next step is to design relevant teaching modules. In this study, the instructional design employed the Problem-Based Learning (PBL) model combined with the Teaching at the Right Level (TaRL) approach, which requires thorough planning and adjustments based on students' cognitive levels.

Based on the results of the diagnostic assessment, the students of class VIII F were categorized into three cognitive levels: low, medium, and high. Accordingly, learning tools such as student worksheets (LKPD) and assessment instruments (pre-test and post-test) were designed in three versions:

version A for the low group, version B for the medium group, and version C for the high group. All learning activities were structured according to the syntax of the Problem-Based Learning (PBL) model to ensure a coherent and meaningful learning experience for the students.

In the first syntax, which is orienting students to the problem, the teacher presented a contextual issue related to dangerous vibrations on a suspension bridge in a village. All students appeared enthusiastic in listening to the teacher's explanation, as the problem was relevant to their daily lives, making it easier for them to understand.

Next, in the second syntax, which involves organizing students for learning, the students were directed to join groups that had been previously formed based on their cognitive ability levels. Although some confusion arose because a few students forgot their group members, the situation was brought under control and the learning process resumed orderly. After joining their groups, the students received student worksheets (LKPD) that had been tailored to their respective cognitive levels.

The next syntax is guiding the group investigation, where students conduct experiments using the PhET simulation application to study the topic of vibrations. Students with medium (B) and high (C) cognitive levels showed considerable enthusiasm in engaging with this activity. Meanwhile, students with low cognitive levels (A) appeared less enthusiastic and experienced difficulties in understanding the experimental procedures. However, with intensive guidance from the teacher, they gradually began to understand and follow the learning activities.

In the syntax of developing and presenting the work results, students are asked to present their observations in front of the class. Initially, students from groups A and B showed less enthusiasm in listening to presentations from other groups, but after receiving reinforcement and guidance from the teacher, they began to demonstrate a more positive attitude and showed appreciation for their peers' presentation process.

In the final syntax, which involves analyzing and evaluating the problem-solving process, students reflect on the learning activities they have undertaken. All groups began to show renewed enthusiasm for learning, especially when discussing the solutions to the problems they had worked on. The discussion became more lively as students actively responded to one another and expressed what they had learned throughout the learning process.

The next stage is reflecting on and evaluating the learning process. Reflection and evaluation are crucial parts of the educational process that must be conducted after the learning activities have taken place. This activity aims to provide feedback to the teacher regarding the effectiveness of the implemented learning process, determining whether improvements are still needed or if the process has been optimal in enhancing student learning outcomes. Reflection and evaluation are carried out not only by the students but also by the teacher as the facilitator of the learning activities. Based on the implementation results of the Problem Based Learning (PBL) model combined with the Teaching at the Right Level (TaRL) approach on the vibration material in class VIII F, positive outcomes were observed, namely an improvement in student learning outcomes. The following are the n-gain test results analyzed using the SPSS application.

Table 3. Students' Pre-Test and Post-Test n-gain Results

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
NGain	28	.21	.75	.4511	.15180
NGain_Persen	28	21.05	75.00	45.1100	15.18001
Valid N (listwise)	28				

The improvement is demonstrated through the analysis of pre-test and post-test data using the SPSS application, which yielded an n-gain score of 0.45. Referring to the n-gain interpretation categories, this value falls into the moderate category ($0.3 < \text{n-gain} \leq 0.7$), indicating an increase in student learning outcomes after participating in learning activities using the PBL model and TaRL approach. This finding aligns with the views of As'Ad and Sukimarwati (2024), who stated that the PBL model and TaRL approach can serve as alternative student-centered learning strategies that adapt to students' abilities and learning needs. Furthermore, the use of PhET media supports the improvement of student learning outcomes. According to Taibu et al. (2021), PhET simulations have successfully contributed to the development of students' scientific processes, knowledge, and skills in science subjects, and significantly enhance students' academic achievement.

The improvement in students' learning outcomes is evident from the analysis of pre test and post-test data conducted using the SPSS application, yielding an n-gain score of 0.45. According to the n-gain interpretation categories, this score falls into the moderate category ($0.3 < \text{n-gain} \leq 0.7$), indicating

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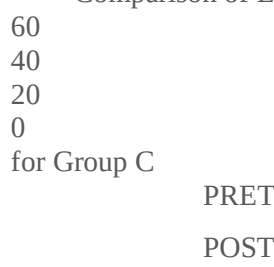
an increase in students' abilities after participating in learning using the PBL model combined with the TaRL approach. This result aligns with the views of As'Ad and Sukimarwati (2024), who stated that the combination of the PBL model and TaRL approach is an effective learning strategy because it is student-centered and adapts to the students' levels of ability and learning needs. Furthermore, the use of the interactive PhET media also proved to support the improvement of learning outcomes. According to Taibu et al. (2021), PhET simulations play an important role in developing students' scientific processes, knowledge, and skills in science subjects, as well as making a significant contribution to improving their academic achievement.



Picture 1. Comparison of Learning Outcomes of Group C

Furthermore, the most significant improvement was seen in students with high cognitive levels (Group C). The data shows that although their pre-test scores were initially low, their post-test scores experienced a substantial increase. The comparison graph of learning outcomes reveals a sharp improvement in this group. This success was influenced by the students' active involvement during the learning process and their ability to effectively complete problem-based tasks. The PBL learning model is considered capable of creating a more engaging learning atmosphere by involving students in problem-solving, thereby increasing their motivation to participate actively (We, 2024). This finding confirms that adjusting teaching methods based on students' cognitive levels has a positive impact, especially for those with better learning readiness. Sakir (2020) also added that students' ability to manage their cognitive thinking processes indicates active involvement during learning, which contributes to achieving better learning outcomes. The implementation of the PBL model combined with the TaRL approach in the science subject also positively affected students' perceptions of the learning experience, as they reported feelings of joy, happiness, and enthusiasm during the learning activities (Ferosa, 2024).

The final stage in the TaRL approach is to design continuous learning improvements, which is a crucial element in enhancing the effectiveness of future learning (Suryadi, 2013). The implementation results showed a significant increase in student engagement, especially when they were directly involved through group activities and the use of concrete learning media. The TaRL approach has proven to have a positive impact on improving group learning abilities, thereby contributing to better student learning outcomes (Puspitaningrum, 2024). Learning media play an important role in supporting the learning process because they provide opportunities for students to observe objects directly, allowing them to gain more meaningful learning experiences (Tarigan & Siregar, 2022). The use of concrete media not only improves conceptual understanding but also increases learning motivation and strengthens students' long-term memory. Based on these findings, teachers can design more varied learning strategies, such as group-based learning, educational games, and grouping students according to individual learning styles. The PBL learning model combined with the TaRL approach, supported by media appropriate to students' cognitive levels, has proven effective in increasing their engagement and understanding. Students tend to grasp basic concepts more easily and show gradual progress when the learning material is adapted to avoid being too difficult or boring (Nurafita, 2024).

Picture 2. Classroom Learning Activities

CONCLUSION

Based on the research results, it can be concluded that the implementation of the Problem Based Learning (PBL) model combined with the Teaching at the Right Level (TaRL) approach on the topic of vibrations is effective in improving the learning outcomes of eighth-grade students (class VIII F) at SMP Negeri 2 Pakis. This improvement is reflected in an average n-gain score of 0.45, which falls into the moderate category. The success of this learning strategy is supported by grouping students according to their cognitive ability levels, the use of Student Worksheets (LKPD) tailored to students' cognitive levels, and the utilization of the interactive PhET media, which enhances motivation and interest in learning. Therefore, the PBL model combined with the TaRL approach can be considered an effective and responsive alternative learning strategy to meet students' learning needs.

It is recommended to conduct further research that measures students' critical thinking skills and collaboration abilities during the learning process. This study can utilize the Problem Based Learning (PBL) model combined with specific assessment instruments, such as teamwork observation rubrics and critical thinking tests, to obtain comprehensive data. Additionally, the use of interactive learning media and group project assignments is expected to enhance student engagement in critical thinking and effective collaboration, providing clearer insights into the impact of the learning model on the development of these skills.

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