



# Innovative Strategies in Math Education: The Impact of PBL and TaRL on Concept Mastery and Classroom Dynamics

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## ABSTRACT

In scrutinizing the amalgamation of Problem-Based Learning (PBL) and Teaching at the Right Level (TaRL) approach within mathematics pedagogy, extant scholarship scarcely offers a holistic evaluation of their synergistic efficacy. Prior research predominantly accentuates scholastic outcomes, frequently neglecting the ramifications of these models on classroom dynamics, including the nuances of student-teacher interactions and student engagement and participation levels. This study probes the integration of PBL and TaRL models to augment students' comprehension of mathematical principles, employing a mixed-methods research design encompassing qualitative and quantitative methodologies. The investigation centered on seventh-grade students in junior high school, utilizing test instruments to evaluate mathematical comprehension and observational protocols to document student and teacher engagement for enriched insights. Comprehensive qualitative and quantitative data analyses were executed. The findings disclosed significant advancements in students' grasp of mathematical concepts, with observations revealing heightened student engagement and more favorable teacher-student interactions. Statistical analyses evidenced substantial disparities between pre-test and post-test scores ( $p < 0.05$ ). The results proffer recommendations and pragmatic implications for enhancing mathematics education, underscoring the imperative for teacher professional development in deploying this integrative pedagogical model to elevate the quality of mathematics instruction at the secondary school echelon.

**Keywords:** Concept Mastery, PBL model, TaRL Approach

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## INTRODUCTION

According to the heuristic conception of mathematics, mathematics is problem-solving by the analytic method. In the claim of the heuristic conception that mathematics is problem-solving by the analytic process, 'mathematics' is meant the 'real' mathematics of the 'real' mathematicians (Cellucci, 2018). Mathematics in the form of abstract concepts requires problem-solving that is not simple, so it is often considered difficult to understand the concepts. Mathematics education is essential to developing students' critical thinking and problem-solving skills. However, students usually have difficulty understanding mathematical concepts in depth (Mustafa et al., 2019), and students who have difficulty understanding mathematical concepts will cause math learning outcomes not to be optimal (Buyung, 2021). To address this, Problem-Based Learning (PBL) and Teaching at the Right Level (TaRL) approaches have become the focus of attention to improve understanding of mathematical concepts.

Problem-based learning focuses on practical and active learning to investigate and research real-world problems (Rézio et al., [2022](#)). According to Hmelo-Silver et al. ([2017](#)), PBL encourages the development of student's cognitive skills and critical thinking abilities through authentic problem-solving. The research shows that PBL can provide a relevant context and actively motivate students to participate in the mathematics learning process. This approach emphasizes the role of students in being independent and managing their learning, as well as collaboration between students in solving mathematical problems. One of the advantages of the PBL model is that it can encourage the development of critical thinking, problem-solving, and communication skills (van der Vleuten & Schuwirth, [2019](#)). PBL can also allow for working in groups, discovering and evaluating problems, and lifelong learning (Compton et al., [2020](#)).

On the other hand, the TaRL approach aims to tailor learning to students' level of understanding so that each student learns appropriately (Boye & Agyei, [2023](#)). Teaching at the Right Level (TaRL) is a concept developed by Abhijit V. Banerjee and Esther Duflo ([2007](#)) in economics that emphasizes the importance of adapting learning materials to students' level of understanding. This approach ensures students understand the concept before moving on to more complex material. A researcher in education policy development, Singh ([2018](#)) highlighted the success of TaRL in improving student understanding in India. Furthermore, Ahluwalia et al. ([2021](#)) emphasized the importance of adjusting the curriculum to students' level of knowledge, which is effectively synchronized with the Teaching at the Right Level (TaRL) principle. TaRL, as proposed by Banerjee and Duflo ([2017](#)), prioritizes the customization of teaching so that each student can master mathematical concepts before moving on to more complex material.

Specifically, in this article, mathematics is considered a universal science vital in developing various disciplines and modern technology (Anisa et al., [2020](#); Octaviana et al., [2018](#)). According to Anisa et al. ([2020](#)), mathematics can develop students' thinking skills, which include the ability to think critically, logically, analytically, and systematically when viewing and solving problems. Thus, mathematics is one of the disciplines that can develop students' thinking power in understanding and solving a problem, so it is one of the subjects that takes an essential role in learning at school.

The implementation of mathematics learning is closely related to learning outcomes. This is because the success of learning can be seen in student learning outcomes (Octaviana et al., [2018](#)). Furthermore, Fauzia ([2018](#)) said that one of the keys to learning mathematics is a good understanding of concepts. That is, a good concept understanding of the material presented in the learning process will affect the learning outcomes obtained by students. However, learning in schools is not always in line with this. The results of observations made by researchers in junior high schools show that student learning outcomes are still relatively low. In addition, the observations of the implementation of mathematics learning showed that the teacher explained the material using the lecture method, divided

students into several groups, and gave assignments. However, students tend to be passive when participating in discussion activities. In this case, only students with high abilities work on the teacher's tasks, while other students do not contribute to the discussion activities.

Furthermore, when assignments are discussed in front of the class, students' enthusiasm remains insufficient, and some students are not actively engaged in the learning process. The teacher often needs to prompt students to present the results of their discussions. Students continue to struggle with applying the material that has been explained, leading to a suboptimal learning process and subsequently low learning outcomes. These observations underscore the need for serious attention to students' mathematics learning outcomes, particularly from mathematics educators.

Some mathematics education experts have highlighted the importance of the integration between PBL and TaRL approaches in the context of mathematics education. They emphasize that combining these two approaches can improve students' understanding of mathematical concepts. In addition, research shows that applying PBL in mathematics education can help prospective mathematics teachers understand paradigm shifts in teaching mathematics and prepare them for the PBL environment in schools (Lee & Galindo, [2021](#)). As Kilpatrick et al. ([2018](#)) expressed, expert opinion highlights the need to personalize mathematics education further to suit each student's needs and level of understanding. This innovation finds common ground with the growing Teaching at the Right Level (TaRL) approach.

According to Pritchett et al. ([2019](#)), TaRL emphasizes adapting learning materials to students' level of understanding, positively impacting academic achievement and learning motivation. Thus, integrating the PBL model and the TaRL approach in mathematics education will significantly improve students' understanding of mathematical concepts. Through this approach, students can likely learn mathematics more thoroughly, actively, and according to their level of knowledge to develop strong problem-solving and critical thinking skills in the context of mathematics. However, few studies have examined the integration of PBL and TaRL in the context of mathematics education; for example, Tenri's research ([2023](#)) on the integration of PBL and TaRL on Writing Skills focuses on the context of English language learning, Ulfa et al.'s research, ([2023](#)) which discusses the training of Teaching at the Right Level (TaRL) based learning models for elementary school teachers in the context of implementing the Merdeka Curriculum, and Amalia et al.'s research, ([2024](#)) which discusses the design and implementation of learning by applying the Teaching at the Right Level (TaRL) approach and applying the Culturally Responsive Teaching (CBT) approach which connects students' cultural background with material content. Therefore, this study investigated how integrating PBL and TaRL can improve students' understanding of mathematical concepts.

The distinction of this research from previous studies on PBL or TaRL lies in its novel integration of Problem-Based Learning (PBL) with the Teaching at the Right Level (TaRL) approach in

mathematics education. PBL emphasizes active learning through real-world problem-solving, while TaRL ensures that students receive instruction at their appropriate learning level. The integration of these two approaches offers a comprehensive method to address diverse learning needs in mathematics education.

### *Literature Review*

Problem-based learning (PBL) has long focused on developing problem-solving-oriented mathematics learning approaches. PBL emphasizes providing students with a real-world context, allowing them to develop mathematical understanding through exploration and solving concrete problems (Mustafa et al., [2019](#)).

The problem-based learning model is learning oriented towards students as learners through providing authentic problems and solving them using their knowledge or other learning resources. Fauzia ([2018](#)), Fanzeka et al., ([2023](#)), and Asdar et al., ([2023](#)). PBL has been proven effective in improving understanding of mathematical concepts. According to Hmelo-Silver et al. ([2017](#)), this approach allows students to engage in deep and critical thinking processes when facing problems relevant to their daily lives. Meanwhile, the use of learning models can be supported by applying learning approaches based on the characteristics of diverse learners. One of the learning approaches that can be used is the Teaching at the Right Level (TaRL) approach.

The Teaching at the Right Level (TaRL) approach brings a new dimension to addressing students' understanding gaps. Banerjee et al. ([2018](#)) explain that TaRL focuses on tailoring learning materials to students' levels of knowledge, ensuring that each student gets a learning experience that suits their needs. The TaRL approach is one of the learning approaches that orient students to learn according to their ability level. Ahyar et al. ([2022](#)) said that learning using the TaRL approach does not organize students based on grade level and age. Still, learning is designed in groups according to the characteristics of students' ability levels.

Furthermore, Cahyono ([2022](#)) said that the reference in the TaRL approach is learning outcomes. Still, it is adjusted to students' characteristics, potential, and needs, as is learning outcomes, where learner learning outcomes are determined based on teaching evaluations according to their phase or ability level. Educators will assist learners who have not achieved the learning outcomes in their phase to achieve their learning outcomes. Thus, the TaRL approach is a learning approach that can be used to overcome the understanding gap that occurs in the classroom during the learning process. Learning using the TaRL approach is knowing that it organizes learners not tied to grade levels but grouped based on developmental phases or according to the same level of ability of learners (Cahyono, [2022](#)). Grouping learners can be done by administering a diagnostic test to determine the student's ability to learn the material. The test results can group students into low, medium, and high-ability categories.

Integrating PBL and TaRL emerges as a potential solution to improve mathematics learning. Boaler (2016) mentioned that through PBL, students can engage in problem-solving, while TaRL ensures that learning is tailored to each student's level of understanding. Although the integration of PBL and TaRL is promising, some challenges must be overcome. According to Sembiring (2019), the difficulty in designing and presenting problems that suit both models can be a significant obstacle.

Measuring the effectiveness of PBL and TaRL integration requires a holistic evaluation approach. Research by Anderson et al. (2019) shows the importance of using various evaluation methods to understand the impact of integrating these models. Case studies of PBL and TaRL integration implementation in different educational contexts are essential. Research by Fernández et al. (2021) explores the experiences and challenges in integrating these learning models in various educational environments. This research has significant implications in the context of improving mathematics learning. Understanding the current literature review is expected to provide a strong foundation for designing and implementing the integration of PBL and TaRL effectively, improving students' understanding of mathematical concepts.

## **METHOD**

This study employs both qualitative and quantitative approaches within a mixed-methods research design. The qualitative approach was utilized to gain an in-depth understanding of students' and teachers' experiences in implementing the integrated learning model, whereas the quantitative approach was employed to measure the impact of this integration on the understanding of mathematical concepts. Data collection involved classroom observations during the learning process, as well as pre-tests and post-tests, which were subsequently analyzed comprehensively to provide a thorough assessment of the learning strategy's effectiveness. Qualitative data was gathered through observations of student participation, interaction with the material, and responses to the learning strategy. Quantitative data was collected through pre-tests and post-tests to evaluate the improvement in mathematical concept comprehension, analyzed using statistical tests.

The research subjects were seventh-grade students at a state junior high school in South Sulawesi, Indonesia. The instruments utilized in this study included observation sheets and test sheets. The observation sheet encompassed various aspects of the learning activities, such as student participation, interaction with the material, and responses to the learning strategies. Additionally, the test sheet was developed to measure students' understanding of mathematical concepts, comprising questions designed in accordance with the curriculum and incorporating problem-solving applications.

Data collection techniques were conducted through observations during the classroom learning process. Observations during the mathematics learning sessions focused on student interactions, the application of PBL methods, and student responses to the learning activities. Additionally, tests were

administered before and after the implementation of the integrated learning model. The initial test provided a baseline understanding of students' knowledge, while the final test assessed the impact of integrating PBL and TaRL. In this study, one entire class was selected as the sample to focus on the effectiveness of the integrated learning models within a single classroom context. By using one class as the sample, the study was able to gain an in-depth understanding of the intervention's effect on the entire group of students within a homogeneous learning environment. This approach allowed the researcher to track changes before and after the intervention in greater detail and comprehend the classroom dynamics.

Although this study involved only one class, the mixed-methods approach provided rich and comprehensive insights into the impact of integrating learning models on students' and teachers' understanding of mathematical concepts and learning experiences in an authentic context. The initial process of instrument validation was reviewed by experts in the field through consultation to ensure relevance and validity. Subsequently, a pilot test was conducted with a small group of students to evaluate the clarity and accuracy of the instrument. Following this, a reliability analysis was performed, using statistical tests for the test instruments and consistency checks for the observation sheets. The results of these stages were used to refine and finalize the instruments before their deployment in the main study.

Qualitative data analysis, specifically observation data, was carried out using thematic analysis to identify patterns and main themes, including student interactions, levels of engagement, and effective PBL learning strategies. Quantitative data analysis, including pre-test and post-test data, employed statistical tests to compare learning outcomes before and after the intervention. The results of the qualitative and quantitative analyses were used to evaluate the effectiveness of integrating PBL and TaRL models. The research findings were interpreted to provide recommendations and practical implications for enhancing mathematics learning in schools.

## **RESULTS & DISCUSSION**

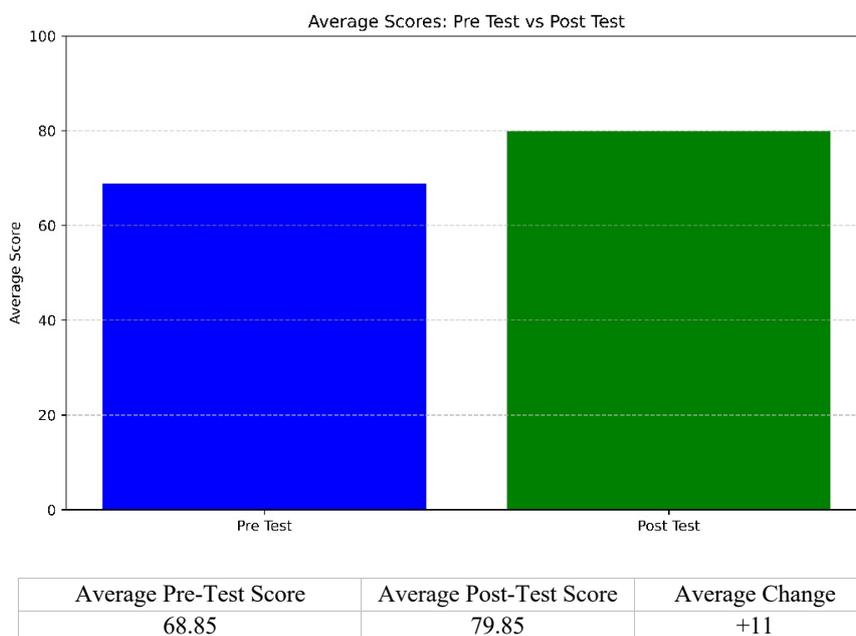
### ***Result***

The integration process of PBL and TaRL was implemented in classroom learning. The study collected relevant qualitative and quantitative data using rigorous measurement instruments: observation sheets to record classroom interactions and specially designed test sheets to measure understanding of mathematical concepts. Before looking at the detailed results of the study, it is essential to remember that this approach was designed to improve the quality of mathematics learning and provide a more personalized approach to students, considering their levels of understanding.

The first step is to give a pre-test. This step aims to measure the knowledge aspects of students before they receive the intervention or learning model under study. The pre-test provides a basis for comparing post-test results after the application of PBL and TaRL so that researchers can assess how much improvement in concept understanding and changes in classroom dynamics are produced by PBL

and TaRL. In addition to measuring aspects of initial knowledge, this step also observes learning activities (attitudinal and psychomotor aspects). Observations help assess how students respond to learning through participation, interaction with the material, and responses to learning strategies.

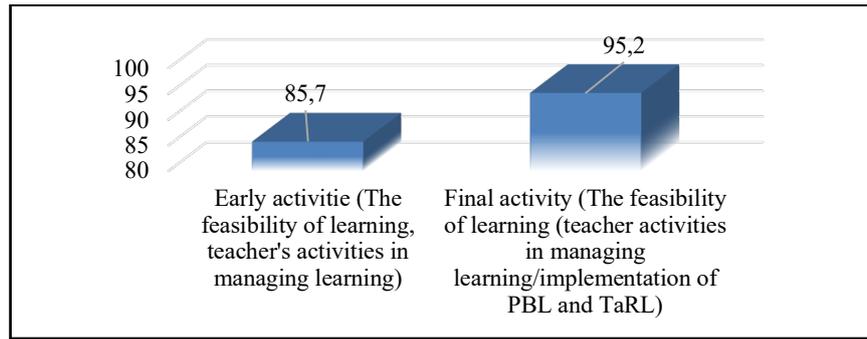
In the next step, the researcher designs the learning according to the initial data by identifying areas that need special attention or improvement. This helps implement PBL and TaRL to better suit the student's needs. The last step is to give a post-test, including making final observations (attitudinal and psychomotor aspects) after PBL and TaRL are implemented. The data and research results are described as follows:



**Figure 1.** Results of Pre-Test and Post-Test Statistical Analysis  
(Knowledge Aspect)

The average value of the pre-test score measured before the implementation of the learning model was 68.85, while the average value of the post-test score measured after the implementation was 79.85. The average difference between the post-test score and the pre-test score is +11. A positive value indicates an increase in the average score after implementing the learning model. Thus, the results in Table 1 illustrate a significant increase in the knowledge aspect of students after following the implemented learning model. The higher average post-test score (79.85) compared to the average pre-test score (68.85) indicates that the learning model positively contributed to students' understanding of mathematical knowledge concepts. The average change of +11 indicates a significant improvement from the beginning to the end of learning.

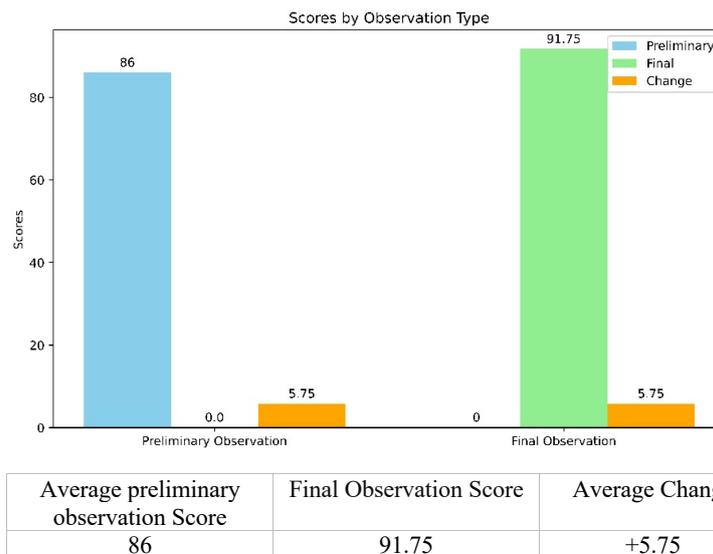
Furthermore, teacher activities in managing learning before the PBL Model and TaRL approach are implemented have differences after implementing the model and strategy.



**Figure 2.** Practical Score

The interpretation of the score of 85.7 indicates that this score reflects the feasibility of learning at the initial implementation stage. The higher the score, the better the feasibility of learning at the beginning of implementation. Teachers' activities in managing learning or implementing PBL and TaRL in the early stages can affect the quality of learning and student engagement. The interpretation of the score 95.2 indicates that this score reflects the feasibility of learning at the final stage of implementation. An increase in the score from the initial to the final stage shows the effectiveness of improvements or adjustments made during the learning process. A high score in the final stage can reflect the teacher's success in managing learning well or implementing PBL and TaRL effectively. The change in scores from the initial to the final stage indicates the extent to which learning has progressed and the effectiveness of teacher activities in managing learning. The more significant the difference between the initial and final scores, the more positive the impact achieved in improving learning quality and student engagement.

In the aspect of assessing student attitudes, the data in Figure 3 is obtained.

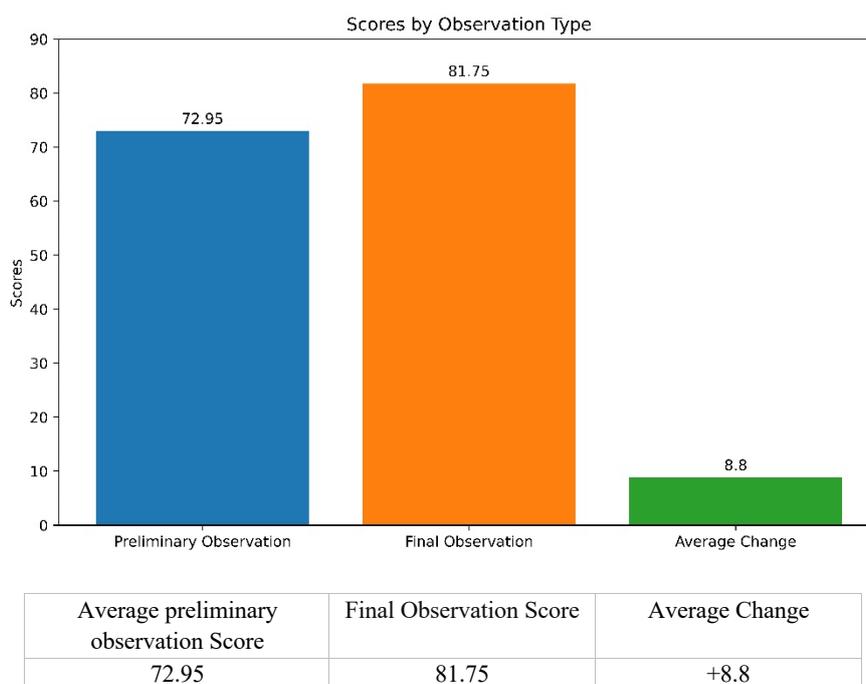


**Figure 3.** Results of Statistical Analysis of Preliminary and Final Observations (Affective Aspect)

Figure 3 shows that the average value of the initial observation score measured before the implementation of learning by implementing the PBL model and TaRL approach was 86, while the average value of the final observation score measured after implementing the PBL model and TaRL approach was 91.75. Average Change +5.75. The acquisition of the score is the average difference between the final observation score and the initial observation score. A positive value indicates an increase in the average effective score after the observation period.

Thus, the results in Figure 3 reflect a significant improvement in the affective aspect based on comparing the initial and final observation scores. The higher average final observation score (91.75) compared to the average initial observation score (86) indicates an improvement in the affective responses or attitudes of the research subjects. The average change of +5.75 suggests improved affective aspects during the observation period.

In the aspect of assessing students' skills, the data in Figure 4 is obtained.

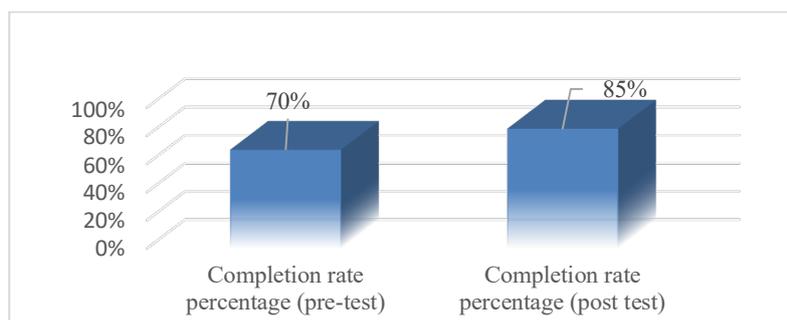


**Figure 4.** Results of Statistical Analysis of Preliminary and Final Observations (Psychomotor Aspect)

Figure 4 provides the statistical analysis results for the initial and final observations on psychomotor aspects. The average score in the initial observation was 72.95. This reflects the average value of all data taken at the initial observation stage related to psychomotor elements, while the average score at the final observation was 81.75. This reflects the average value of all data taken at the final observation stage related to psychomotor aspects. The average change was +8.8. This demonstrates the

difference between the average score in the final observation and the average score in the initial observation. In other words, there was an average increase of 8.8 points in psychomotor aspects during the observation period. This result illustrates a significant improvement in psychomotor aspects between the baseline and final observations. A positive number on the mean change indicates an improvement in the psychomotor skill or response observed during the study period. This change may reflect the effectiveness of an intervention or program implemented during the observation.

Learning assessment during this study covered three aspects, namely knowledge, affective, and psychomotor. The overall data is organized as follows.



**Figure 5.** Learning Completion Percentage

Figure 5 illustrates the percentage of learning completion by comparing the initial and final completion rates. Learning Completion Percentage (Initial) is the percentage of learning completion at the initial stage. In this example, the initial learning completion rate is 70%. It reflects how much learning material has been mastered or completed by participants at the beginning of a specific period. Completion Rate Percentage shows the percentage of learning completion at the end stage or after a certain period has passed. In this example, at the end of the period, the learning completion rate increases to 85%. This reflects the extent to which participants have completed the learning material during the period. Percentage Change is the difference between the Learning Completion Percentage at the end of the period and the Learning Completion Percentage at the beginning. In this example, the percentage change is +15%, which indicates a 15% increase from the start to the end of the period. This shows a significant improvement in the learning completion rate during the period.

Looking at Figure 5, we can conclude a positive increase in the percentage of learning completion from the beginning to the end of a given period. This indicates the progress of the participants in completing the given learning materials. A decrease in the percentage of learning completion in the final stage would suggest that participants have not completed most of the learning materials. Based on the results of data analysis involving knowledge, affective, and psychomotor dimensions in the context of integrating Problem-Based Learning (PBL) and Teaching at the Right Level (TaRL) models in mathematics learning, it can be concluded that Analysis of test data shows a significant increase in understanding of mathematical concepts, Students who follow learning with PBL and TaRL approaches

show a higher increase in post-test scores. Student affective observations indicated higher levels of engagement and activeness. In addition, changes in student participation and interaction between teachers and students reflected the development of psychomotor skills. Integrating PBL and TaRL allowed students to apply mathematical concepts in problem-solving, improving their practical skills. Thus, the results of data analysis consistently show that integrating PBL and TaRL models effectively enhances the understanding of mathematical concepts in the knowledge dimension. Meanwhile, observations on the affective and psychomotor dimensions illustrate the positive impact on students' motivation and practical skills. Given the improvements in these three dimensions, this approach holds promise as a holistic learning method to improve the quality of mathematics learning at the secondary school level.

### ***Discussion***

The results of this study support the literature showing the effectiveness of PBL and TaRL models in improving mathematics learning. Observations and test analysis imply that this approach provides a more relevant learning context and is responsive to students' diverse levels of understanding. The results showed that integrating Problem-Based Learning (PBL) and Teaching at the Right Level (TaRL) models significantly improved the knowledge of mathematical concepts. According to Hiebert and Carpenter (2019), the PBL approach can stimulate deep mathematical thinking, allowing students to build a solid understanding of concepts. This can be seen from the consistent increase in post-test scores. The PBL approach will enable students to face real-world problems, motivating them to understand math concepts more deeply. According to Boaler (2022), active engagement in the mathematics learning process can increase students' interest and motivation, creating a more positive learning experience. The integration of PBL and TaRL positively influences students' affective dimension. In addition, integrating PBL with TaRL can improve students' writing skills (Tenri, 2023); this skill is suitable for students, especially in understanding contextual mathematical problems to be modeled in mathematics. TaRL is a learning approach that directs students to learn based on their ability level, while PBL is a problem-based learning model that can be applied to train students in analytical skills. Both can be used together to increase students' interest in learning and skills in problem-solving (Nabella et al., 2023). TaRL focuses on orienting students to learn based on their ability level, while PBL is a problem-based learning model that can be applied to train students in analytical skills. Kanyesigye et al. (2022) suggested the importance of teachers understanding PBL in PBL, increasing their knowledge of PBL concepts, increasing competence in PBL, increasing the perceived value of PBL, and making PBL implementation.

The successful integration of PBL and TaRL models can also be attributed to the active engagement of students in the learning process. Involving students in real-world problem-solving and presenting materials tailored to their respective levels of comprehension can significantly enhance motivation and learning outcomes. Despite these positive results, it is important to acknowledge that

challenges may arise in designing appropriate PBL problems and customizing materials to align with each student's level of understanding. Therefore, this approach necessitates robust support from educators and a meticulous approach to planning and material presentation. The significance of PBL and TaRL integration in enhancing mathematical understanding is underscored in the "Teaching at the Right Level" initiative. This approach, developed by Banerjee et al. (2018), emphasizes the importance of aligning learning materials with students' level of understanding, thus giving relevance and significance to each stage of learning.

Integrating PBL and TaRL can be a holistic approach that addresses not only the knowledge aspects but also students' affective and psychomotor aspects. This aligns with NCTM's (National Council of Teachers of Mathematics) view, which emphasizes the importance of developing the whole individual through meaningful mathematics learning (NCTM, 2022). According to NCTM (2023), PBL integration can help students develop critical thinking skills and the ability to apply mathematical concepts in authentic contexts.

Understanding the results of this study can contribute to developing a more effective mathematics learning model. The practical implication is the need for teacher training in designing and implementing this learning model and supporting improving the quality of mathematics learning at the secondary school level.

## CONCLUSION

From the preceding discussion, it can be concluded that implementing a problem-based learning (PBL) model, combined with teaching at the right level (TaRL), significantly enhances learning outcomes. The integration of PBL and TaRL has augmented students' comprehension of mathematical concepts. The PBL model situates learning within a real-world context, fostering critical thinking, while the TaRL approach tailors' instruction to students' proficiency levels. Classroom observations indicated a marked improvement in learning dynamics. Teacher-student interactions became more engaged and collaborative, cultivating a more dynamic and interactive educational environment. Adjusting instructional materials and strategies based on students' prior knowledge is essential, particularly within the frameworks of PBL and TaRL, to ensure each student receives an appropriate and personalized learning experience. The teacher's role in guiding the learning process, offering support, and providing continuous feedback is pivotal. Teachers serve not only as facilitators but also as adaptors to students' individual needs. This research lays the groundwork for developing more contextual, dynamic, and responsive mathematics learning strategies that accommodate the diverse levels of student understanding. The practical implications of this research can assist educators and policymakers in designing a more adaptive and pragmatic curriculum to enhance the quality of mathematics education in schools.

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