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Effectiveness of Problem-Based Learning with the Teaching at the Right Level Approach on Students' Mathematical Concepts Understanding Ability

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ABSTRACT

Mathematical concept comprehension ability reflects students' proficiency in restating mathematical ideas and applying them in various contexts. This study aims to describe the results of problem-based learning combined with the Teaching at the Right Level (TaRL) approach on the mathematical concept understanding ability of junior high school students. This research uses a quantitative method with a pre-experimental design of the One-Shot Case Study type. The research subjects are students from class VIII-K of SMP Negeri 8 Tasikmalaya, who were selected purposively. Data was collected through essay tests that had been validated for content and reliability. The analysis results show that the data is normally distributed and the obtained t-value is greater than the t-table value (3.534 > 1.697), indicating that problem-based learning with the TaRL approach yields learning outcomes that exceed the learning achievement criteria (KKTP). These findings indicate that an integrative problem-based learning model with TaRL has the potential to improve students' understanding of mathematical concepts across various ability levels.

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Introduction

Education is the main pillar for national progress, so innovations in learning models and approaches are continuously developed to create effective and meaningful learning experiences (Riowati & Yoenanto, 2022). Teachers play a role in optimizing the learning process, especially in mathematics education. According to Siswanto et al. (2024), mathematics makes a significant contribution to building students' logical, analytical, and critical thinking abilities. Mathematics learning aims to sharpen students' ability to understand mathematical concepts, which is the

ability to identify, interpret, and apply mathematical concepts in various situations (Lubis et al., 2024).

In the learning process, the ability to understand mathematical concepts is an important foundation because it plays a very significant role in developing various other mathematical skills, such as communication skills, problem-solving skills, logical thinking skills, the ability to make connections between concepts, the ability to present information accurately, critical thinking skills, and creative thinking skills in the context of mathematics (Darwanto, 2019). Especially in mathematics, concepts are interconnected, making them easier for students to understand once they have mastered previous concepts. This aligns with Sari (2022) opinion that the ability to understand mathematical concepts is the main foundation of mathematical thinking and problem-solving, encompassing the skills of finding, explaining, translating, interpreting, and drawing conclusions from mathematical concepts based on one's own understanding. This expertise also includes the ability to rephrase, interpret, and communicate mathematical concepts in various forms, as well as draw conclusions based on existing knowledge. Students can solve problems mechanically and explain why they did each step if they have a good grasp of math concepts (Affriyenni et al., 2020). This improves their reasoning skills and gets them ready for more difficult problems.

Interactive and relevant learning strategies to help students master mathematical concepts include problem-based learning. John Dewey (in Nurdyansyah & Fahyuni, 2016) stated that problem-based learning is understood as a form of reciprocal interaction between stimuli and responses, reflecting a two-way relationship between the learning process and the surrounding environment. This model emphasizes the dynamic and ever-evolving connection between students and the learning environment. This means that learning is not merely a passive response to stimuli provided but rather an interactive process in which individuals actively engage with their environmental context. Therefore, problem-based learning combines these two components into a complete and comprehensive learning system, thus enabling the achievement of a more comprehensive and sustainable understanding. Problem-based learning in mathematics aids students in comprehending and utilizing mathematical concepts in daily life (Hidayati & Wagiran, 2020), such as employing linear equations to calculate distance traveled or to examine the correlation between price and quantity of goods. However, the effectiveness of problem-based learning models is influenced by students' readiness levels, necessitating differentiated approaches such as Teaching at the Right Level (TaRL), which adjusts learning activities to students' abilities.

Based on interviews with eighth-grade math teachers at SMP Negeri 8 Tasikmalaya, the material presented does not consider students' different abilities, making it difficult for students to understand concepts and practice problems, such as writing mathematical models from statements in the problems, and students are unable to correctly understand the steps of solving problems in algebraic form. These problems indicate that students' understanding of mathematical concepts needs to be optimized, especially regarding the concepts of linear equations and inequalities in one variable, which are prerequisites for understanding the equation of a straight line. Teacher-centered teaching methods that are not linked to real-world contexts make the material difficult to understand, especially for students with weak basic arithmetic skills. This leads to student boredom and lack of motivation, ultimately hindering their ability to grasp concepts deeply, particularly if there is no constructive feedback and additional support, especially from the teacher. If this is not addressed immediately, students will find it difficult to connect theory with practice, resulting in their understanding being limited to rote memorization without a deep grasp of the concepts.

One solution relevant to the situation or problems found in the field is through the Teaching at the Right Level (TaRL) approach. According to Banerjee et al. (2016), the

Kognitif: Jurnal Riset HOTS Pendidikan Matematika
https://doi.org/10.51574/kognitif.v6i1.3379 Volume 6, No 1, January - March 2026, pp. 216 – 226

Teaching at the Right Level approach aims to address learning gaps that often arise due to the implementation of a uniform curriculum in classes that are heterogeneous in ability and to ensure students have a solid learning foundation before they move on to more complex material. This approach groups students based on their skill levels, allowing teachers to provide more effective and relevant learning for the students. Through the implementation of the Teaching at the Right Level (TaRL) approach, educators need to conduct an initial assessment in the form of a diagnostic test to identify students' initial abilities, characteristics, and learning needs. Collaboration of problem-based learning with TaRL results in structured, adaptive, and contextual learning (Mustafa et al., 2024), which accommodates students' differing abilities and enhances their active participation.

Based on the description above, there is still a gap between students' initial abilities and the demands of advanced material in mathematics learning, especially regarding linear equations. Problem-based learning has the potential to help students understand mathematical concepts, but its effectiveness decreases when students' abilities vary greatly. The Teaching at the Right Level (TaRL) approach can be a solution because it focuses on grouping students based on their actual abilities. This research assesses the effectiveness of the problem-based learning model with the Teaching at the Right Level approach in improving the mathematical concept comprehension skills of junior high school students.

Method

Research Design

The research method used is quantitative research, which is based on research results in the form of numerical data. The implementation of problem-based learning with TaRL begins with student orientation toward the problem, where the teacher conducts a diagnostic test to identify students' initial abilities, followed by providing students with contextual problems to observe and understand. The next stage is organizing student learning groups. The teacher prepares various learning activities by adjusting teaching materials to the ability levels of the previously grouped students. The teacher also ensures that each student in the group understands the problems according to their ability levels. The third stage is guiding the investigation individually or in groups. The teacher supervises student involvement in the discussion process and the division of tasks in gathering the information or data needed to solve the problem. Next, in the fourth stage, which is developing and presenting the work results, students discuss solutions to the analyzed problems, while the teacher provides guidance in preparing the report to be presented by the students. The final stage is to analyze and evaluate the problem-solving process. In this stage, the teacher facilitates presentations between groups, encourages appreciation and discussion through suggestions from other groups, and the presenting students summarize and draw conclusions based on the feedback received.

Pre-Experimental Design is the design used in this research. This design falls into the category of quasi-experiments because it does not fully meet the criteria of pure experiments. In this design, not all variables are strictly controlled by the researcher, due to the absence of a control group, which allows external variables to influence the dependent variable and potentially affect the research results. The Pre-Experimental Design was chosen in this study to examine the effectiveness of problem-based learning combined with the TaRL approach in honing students' mathematical concept comprehension skills, using the One-Shot Case Study form, a scheme involving only one group of subjects given a specific treatment, with the results observed without comparison to another group. The selection of this design is based on the

researcher's objective to determine the impact of the treatment given. The scheme of the design can be illustrated as follows:

Figure 1. Research Design

Explanation:
X: Learning using problem-based learning with a TaRL approach.
O: Test of students' mathematical concept understanding ability.

In the design above, only one sample class is involved without a comparison class. The class received treatment in the form of problem-based learning combined with the TaRL approach, followed by observation to assess the results of the treatment.

Population and Sample

The population in this study consists of 363 eighth-grade students from SMP Negeri 8 Tasikmalaya across 11 classes. The sample selected used Cluster Sampling, which is the random selection of samples based on groups, not individuals. This technique was chosen because each class is considered to have relatively uniform characteristics, given that class divisions are not based on academic performance. Based on the random selection, class VIII K with 31 students was designated as the sample in this study.

Instrument

The research instrument is an essay test designed to assess students' understanding of mathematical concepts. The test consists of three essay questions focusing on the topic "Linear Equations." The details of the indicators and aspects measured in the test are displayed in Table 1.

Table 1. Blueprint for the Mathematical Concept Understanding Ability Test

Learning Outcomes	Learning Objectives	Ability Indicator	Question Number
Students are able to interpret, evaluate, and formulate solutions to problems related to the use of linear function concepts, straight line equations, and line slopes on the Cartesian coordinate system.	1. Understanding the form of linear equations/straight line equations 2. Understanding the concept of gradient 3. Understanding the concept of the linear equation form 4. Describing another form of the linear equation 5. Applying the concept of linear equations in solving problems	Giving examples and non-examples of a concept Classifying objects according to certain characteristics according to their concept Presenting concepts in various forms of mathematical representation Developing the necessary and sufficient conditions of a concept Restating a concept Using, utilizing, and selecting specific procedures or operations Applying concepts or algorithms to problem-solving	1 2 3 1,2,3 2,3

Kognitif: Jurnal Riset HOTS Pendidikan Matematika
https://doi.org/10.51574/kognitif.v6i1.3379 Volume 6, No 1, January - March 2026, pp. 216 – 226

The validity and reliability tests utilize SPSS assistance to examine the validity and reliability levels of the test questions on mathematical concept comprehension, with the following validity results.

Table 2 Validity Test Results

Question Item	r_{hitung}	r_{table} $(n = 18)$	Level	Conclusion
Number 3a	0,902	0,468	Very High	Valid
Number 3b	0,897		Very High	Valid
Number 2	0,774		High	Valid
Number 1	0,716		High	Valid

The validity of the test items is when $r_{hitung} > r_{table}$. By consulting the critical value of the product moment correlation with $n = 18$ and $\alpha = 5\%$, the r_{table} value is obtained. The correlation coefficients obtained based on the table above are 0.902 for item number 3a; 0.897 for item number 3b; 0.774 for item number 2; and 0.716 for item number 1, thus it can be concluded that these 3 test items are valid. The results of the reliability test using SPSS are interpreted in Table 3.

Table 3. Reliability Test Results

Cronbach's Alpha	$r_{table}(n = 18)$	Level	Conclusiom
0,822	0,468	High	Reliable

The Cronbach's Alpha value is 0.822, which falls within the high reliability criteria ($0.705 < 0.90$), making the questions suitable for use in this research.

Data Collection

Data were collected through essay tests and diagnostic tests to measure students' understanding of mathematical concepts and their ability levels, with criteria for grouping students based on ability levels. The criteria for grouping students based on ability levels, modified from Anggreaena et al. (2022), are presented in the table below.

Table 4 Criteria for Determining Student Groups

Score Calculation	Category
$X > Mi + Sbi$	Very Skilled
$Mi - Sbi \leq X \leq Mi + Sbi$	Skilled
$X < Mi - Sbi$	Need Guidance

Explanation:
X : Assessment result value
Mi : Ideal mean $= \frac{1}{2}(highest\ value + lowest\ value)$
Sbi : Ideal standard deviation $= \frac{1}{6}(highest\ value + lowest\ value)$

Data Analysis

The test results obtained at the end of the learning process were then processed using IBM SPSS Statistics 24. The steps of data analysis in this study include descriptive statistics, calculation of concept understanding ability criteria, and hypothesis testing, which consists of normality tests. If the data is normally distributed, it is followed by a One-Sample T-Test. However, if the data is not normally distributed, hypothesis testing uses the non-parametric Wilcoxon Signed-Rank Test.

Research Results

The results of the data analysis obtained using descriptive statistical techniques illustrate the characteristics of the post-test data, and the t-test is used to examine whether the population mean μ is equal to a certain value μ_0 in Table 5.

Table 5. Descriptive Statistics Results

	N	Range	Minimum	Maximum	Sum	Mean	Std. Deviation	Variance
Results of the Mathematical Concept Understanding Ability Test	31	31	55	86	2205	71.13	8.082	65.316
Valid N (listwise)	31							

From the table above, it is known that among 31 students, the highest score on the mathematical concept understanding ability test was 86, while the lowest score was 55, with an average score of 71.13. The distribution of the frequency of students' mathematical concept understanding test scores is shown in Table 6.

Table 6. Frequency Distribution of Mathematical Concept Understanding Ability

Value Range	Frequency	Percentage (%)	Category
$0 \leq P < 60$	5	16,13	Low
$60 \leq P < 75$	12	38,71	Currently
$75 \leq P \leq 100$	14	45,16	High
Amount	31	100	

Based on Table 6, it was found that the frequency distribution of the mathematical concept understanding ability test showed a percentage of 45.16% or 14 students in the high category, a percentage of 38.71% or 12 students in the medium category, and a percentage of 16.13% or 5 students in the low category. The number of students who meet the learning achievement criteria (KKTP) is presented in Table 7.

Table 7. Student Achievement in KKTP

Value Range	Frequency	Percentage (%)	Category
$67 \leq x < 100$	23	74,19	Achieving KKTP
$x \leq 66$	8	25,81	Not Achieving KKTP
Amount	31	100	

Based on Table 7, it is known that 23 students (74.19%) achieved the KKTP, while 8 students (25.81%) did not achieve it. Therefore, it can be concluded that the majority of students were able to achieve the specified KKTP. As for the achievement of students' mathematical concept understanding, it is reviewed from the TaRL group presented in Table 8.

Kognitif: Jurnal Riset HOTS Pendidikan Matematika
https://doi.org/10.51574/kognitif.v6i1.3379 Volume 6, No 1, January - March 2026, pp. 216 – 226

Table 8. Achievement of Mathematical Concept Understanding Ability from the Perspective of the TaRL Group

Value Range	Student Frequency in the TaRL Group			Percentage (%)			Category
	PB	M	SM	PB	M	SM	
$0 \leq P < 60$	2	1	2	7,41	3,70	5,13	Low
$60 \leq P < 75$	2	5	5	7,41	18,52	12,82	Currently
$75 \leq P \leq 100$	5	3	6	18,52	11,11	15,38	High
Amount	9	9	13	33,33	33,33	33,33	
		31			100		
Average Ability Test Score	72,33	70,89	70,46				

Based on Table 8, the frequency of students who scored in the high category on the mathematical concept understanding ability test was 14, which includes 5 students (18.52%) from the need for guidance group, 3 students (11.11%) from the proficient group, and 6 students (15.8%) from the very proficient group. In the moderate category, there are 12 students, consisting of 2 students in the need guidance group with a percentage of 7.41, 5 students in the proficient group with a percentage of 18.52, and 5 students in the very proficient group with a percentage of 12.82. In the low category, there are 5 students: 2 students from the needs guidance group with a percentage of 7.14%, 1 student from the proficient group with a percentage of 3.70%, and 2 students from the very proficient group with a percentage of 5.13%. In addition, the average score on the students' mathematical concept understanding ability test was 72.33 for the group needing guidance, 70.89 for the very skilled group, and 70.46 for the highly skilled group. The analysis results show that the TaRL approach with problem-based learning is more effective for the group needing guidance, with an average mathematical concept understanding test score higher than the skilled and very skilled groups. Based on the results and analysis, students' ability to understand mathematical concepts with the problem-based learning model and the TaRL approach falls into the moderate category, with an average of 71.13% and 74.19% of students achieving KKTP.

Then, hypothesis testing was conducted to assess the effectiveness of problem-based learning with the Teaching at the Right Level approach on students' mathematical concept understanding ability. The first step is to conduct a normality test to determine whether the posttest scores are normally distributed or not. This normality test uses the Shapiro-Wilk method with a significance level of 5% because the number of samples studied is less than 50. The testing criteria are as follows.

Research Hypothesis :

H_0: The sample comes from a normally distributed population.

H_1: The sample does not come from a normally distributed population.

Conditions :

H_0 is accepted if the p-value $\geq 0{,}05$ and H_0 is rejected if the p-value $< 0{,}05$.

Table 1. Normalitas Test

Significance Value	Alpha Value	Decision
0,087	0,05	H_0 accepted

Based on Table 9, the significance value of 0.087 > 0.05 means H_0 is accepted, so the sample is normally distributed. The second step is to conduct a one-sample t-test to determine whether the population mean μ is equal to a certain value μ_0, which is the KKTP value. The hypothesis for the one-sample t-test (right-tailed test) is as follows:

$H_0 : \mu \leq \mu_0 \leftrightarrow H_0 : \mu \leq 66$

$H_1 : \mu > \mu_0 \leftrightarrow H_1 : \mu > 66$
Explanation:
μ_0 = Learning mastery score
H_0 = The average score is not more than the passing grade
H_1 = The average score is higher than the passing grade

Table 2. T Sample t-test

t_{count}	$t_{table(0,05;30)}$	Decision
3,534	1,697	H_0 rejected

Based on the results displayed in the table, if $t_{table} < t_{count}$ then H_0 rejected. Problem-based learning with the TaRL approach effectively improves students' mathematical concept comprehension skills.

Discussion

The problem-based learning model with the TaRL approach effectively enhances students' understanding of mathematical concepts, achieving learning objectives with an attainment rate of >66%. This finding aligns with the guidelines from Permendikbud (2014), which state that learning is considered effective if it meets the predetermined learning objectives. This learning model is very suitable for honing students' conceptual understanding. Problem-based learning provides students with a real context for building understanding, solving problems, and developing critical thinking skills. On the other hand, the TaRL approach allows the learning process to be tailored to each student's ability level through appropriate grouping. This creates a more comprehensive and meaningful learning atmosphere, as the material is delivered according to the needs and potential of each ability group. Students in the lower ability group can also participate actively in learning because the material and activities have been adjusted. In addition, this approach encourages students to work collaboratively, thereby increasing their engagement in the learning process.

This is supported by research As'ad et al. (2024), which states that the problem-based learning model and the teaching at the right level approach need to be implemented by teachers in the classroom because they can enhance students' creativity and cognitive abilities in learning as well as the learning outcomes they achieve. In line with the research findings from Cuhanazriansyah et al. (2023) that the implementation of the collaboration between the Problem-Based Learning model and Teaching at the Right Level can improve the learning outcomes of students in class X at SMKN 01 Kota Bengkulu, with an increase in learning completeness from cycle I to cycle II achieving learning completeness. The same conclusion is also drawn by Asrobanni et al. (2024) that the implementation of the PBL model with the TaRL approach can improve the learning outcomes of eighth-grade students at SMP Negeri 10 Palembang. This benefit is seen from the increase in the percentage of student learning outcomes from cycle I to cycle II and the average ability of the students. The implementation of the PBL model with the TaRL approach enhances students' critical thinking, collaboration, and communication skills, resulting in improved learning outcomes. These findings are in line with As'ad et al. (2024) and Rahayu et al. (2024), which show an improvement in cognitive outcomes and academic achievement of 8th-grade students at SMP Model Terpadu Bojonegoro. This benefit is seen from the completeness of student learning outcomes from cycle I to cycle II. Research by Ahmad & Setiadi (2023) supports that the TaRL approach and the PBL model assisted by LKPD can address learning problems, improve learning outcomes, and achieve learning objectives. The improvement of cognitive skills, independence, collaboration, and student participation can also be achieved.

Kognitif: Jurnal Riset HOTS Pendidikan Matematika
https://doi.org/10.51574/kognitif.v6i1.3379 Volume 6, No 1, January - March 2026, pp. 216 – 226

Problem-based learning encourages students to build knowledge through real contexts, fostering critical, collaborative, and reflective thinking skills. The TaRL approach allows for adaptive learning according to ability levels, making it more targeted. These findings are in line with Banerjee et al. (2016) and Firdaus et al. (2017), which demonstrate the effectiveness of TaRL and problem-based learning in improving students' academic achievements and understanding of mathematical concepts. Thus, the combination of problem-based learning and the TaRL approach effectively enhances students' understanding of mathematical concepts, especially in low-performing groups or groups needing guidance. Contextual and adaptive learning can create a more equitable and inclusive learning process.

Conclusion

Based on the research results that have been conducted, it can be concluded that the application of the problem-based learning model combined with the Teaching at the Right Level approach has proven to be effective because it has a positive impact on improving students' mathematical concept understanding abilities. This conclusion is reflected in the post-test results, which show that the majority of students achieved learning completeness and demonstrated a significant improvement in concept understanding after participating in problem-based learning with the TaRL approach. The limitations of this study are that the research scope is confined to one school with a relatively small sample size, so the effectiveness of the learning applied in this study does not yet fully reflect the impact on the overall development of students' abilities. Therefore, the researcher suggests that future researchers expand their research scope, such as using a comparative class method and a sufficient sample size.

Conflict of Interest

The author declares no conflict of interest.

Authors' Contributions

The first author, J., was responsible for developing the study, designing the research instruments, conceptualizing the research idea, collecting the data, analyzing and processing the data, and drafting the results and discussion. The second author, S.V.D., and the third author, H.Y., contributed by revising the research instruments, the results, and the discussion, and by approving the final version of the manuscript. The total contribution percentages for the conceptualization, writing, and revision of this article were as follows: J.: 50%; S.V.D.: 25%; and H.Y.: 25%.

Data Availability Statement

The author declares that data supporting the results of this study will be made available by the corresponding author, [J.], upon reasonable request.

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