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The Effect of the TaRL Approach Based on Process Differentiation on Problem-Solving Ability

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ABSTRACT This study aims to evaluate the impact of the Teaching at Right Level (TaRL) approach based on process differentiation on the problem-solving abilities of eighth-grade students at UPT SPF SMPN 33 Makassar, focusing on the core topic of Vibrations and Waves. The research employs a quasi-experimental design with a pretest-posttest framework. Data collection was conducted using a problem-solving ability test instrument. The results indicated that, before implementing the TaRL approach, the average score for students' problem-solving abilities was 32.33, which was classified as sufficient. Following the implementation, the average score is 65.77, which falls into the good category. This improvement reflects an N-Gain of 0.49, indicating a moderate increase. Additionally, the hypothesis test yielded a p-value of 0.001, which is less than 0.05, confirming that the hypothesis is accepted. The effect size calculation yielded a value of 0.862, indicating a significant effect.

Keywords: Teaching at the right Level, Problem-solving ability, Learning differentiation

1. INTRODUCTION

There are four main competencies that students must possess in the 5.0 era: creativity, critical thinking and problem-solving, communication, and collaboration. Therefore, to develop these skills, educators need to implement learning strategies that facilitate and optimize 21st-century skills (Widana et al., 2018). Meaningful learning experiences must be engaging, inspiring, fun, and challenging. These learning experiences must motivate students to participate actively while providing opportunities for initiative, creativity, and independence, tailored to their respective talents, interests, and developmental levels (Manzis, 2024).

Indonesia's education system faces several ongoing problems, including gaps in educational quality, limited resources, and inadequate teacher training (Chang et al., 2014). These problems are particularly evident in secondary schools, which are the transition phase for students from primary education. During this process, learning gaps can widen, making it increasingly difficult for students to meet curriculum expectations. This can result in a lack of engagement and a decline in academic performance (Gustine & Insawan, 2019).

Problem-solving skills are essential for students because they offer numerous benefits, especially in helping them see the relevance of the knowledge they gain to real-life applications (Amri & Abadi, 2013). The reality of learning in Indonesian schools shows that problem-solving is still rarely practiced (Amir, 2015). The OECD (2019) reported that Indonesia was ranked 71st in 2018 and 67th in 2022, with an average score decreasing from 396 in 2018 to 383 in 2022. This means that Indonesian students' understanding of science has not made significant progress and is actually far behind the international average in this category, which is 485.

One of the main problems in formal education (schools) today is students' limited capacity to absorb information. Absorption capacity is defined as the ability of students to absorb or master the material they are studying in accordance with the subject matter taught by educators in the teaching and learning process. When associated with everyday life. As a result, upon graduation, students are often proficient in theory but lack practical application (Yulistiawati et al., 2019).

So far, science instruction has not sufficiently focused on the substance of problem-solving (Chen et al., 2019). Students often memorize mathematical concepts, which can lead to a lack of problem-solving skills. Students are

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less motivated to generate their own ideas and rely more on educators' active role in the teaching and learning process (Damianti & Afriansyah, 2022; Verschaffel et al., 2022). Many educators find it challenging to adjust their teaching methods to accommodate the varied learning needs and developmental stages of early adolescents. Furthermore, the shift from elementary school to high school introduces specific obstacles for students (Eccles & Roeser, 2011; Gustine & Insawan, 2019; Sofyan & Susilawati, 2021)

Several factors can affect problem-solving skills, including students not understanding the problems presented because they habitually work on routine questions. Some students grasp the questions and follow the steps but fail to double-check their work, leading to less accurate results (Adhyan & Sutirna, 2022). This aligns with Elita et al. (2019), who noted that students struggle with solving story problems, formulating questions, outlining the steps to find solutions, and addressing the presented challenges. Consequently, it is essential to support students to actively engage in problem-solving (Sriwahyuni & Maryati, 2022). Additionally, factors that influence problem-solving ability include when students are asked to form groups and are assigned randomly; in this scenario, only some students work on the task, while the rest rely solely on their friends (Iraka et al., 2023).

Based on observations conducted at the UPT SPF SMPN 33 Makassar, the science learning implemented has not led to the development of problem-solving skills and abilities. Students often struggle to connect the concepts they have learned to phenomena in everyday life. Students also tend to be individualistic, leading to learning gaps among them. The results of an interview with one of the science educators at the school provide an overview of the various learning models used in implementing science instruction, with specific reference to the science materials.

Personalized learning can effectively bridge educational gaps by adapting teaching methods to fit the individual needs and backgrounds of each student (Geel et al., 2019). The TaRL approach focuses on guiding students to learn according to their ability levels, which are categorized as low, medium, or high, rather than based on their grade or age (Ahyar, 2022; Smale-Jacobse et al., 2019). TaRL can be the answer to the problem of understanding gaps that occur in the classroom. Additional information is also used to evaluate the learning activities carried out and assess the extent to which these activities affect the quality of learning outcomes (Triyanto & Prabowo, 2020). This approach is particularly advantageous for students from various backgrounds, as it caters to their unique learning styles and knowledge frameworks (Gay, 2018; Ladson-Billings, 1995)

This method groups students by skill level, making teaching more relevant and practical. With interactive activities and constructive feedback, TaRL increases student engagement and has the potential to close learning gaps (Banerji & Chavan, 2016). The primary advantage of this approach is its ability to accommodate a range of learning styles and preferences. By understanding that students learn in different ways, educators can employ a variety of teaching strategies to support students' diverse learning preferences (Subban, 2006; Tomlinson, 2017; Tomovic et al., 2017).

Based on research conducted by Istiqomah et al. (2024), the application of TaRL can improve students' problem-solving abilities by 84%. Apriliyani et al. (2025) also provide evidence that the TaRL approach is efficacious in enhancing students' problem-solving skills by 86.11%. Furthermore, research by Salihin et al. (2024) shows that applying TaRL can improve problem-solving skills by 81%.

The teaching and learning process using the TaRL approach is a primary factor in training students to engage their thinking. Learning through involvement in thinking and activities can be observed in students' abilities. However, in reality, not all students have the same skills, so the TaRL approach can help students think critically. The success of each student's critical thinking is measured by their ability to complete the given challenges. If students can use the right critical thinking model or strategy to solve everyday problems, they will be better able to solve them (Kusumaningrum et al., 2024).

TaRL is closely related to differentiation. According to Tomlinson (2017), there are four aspects to differentiated learning: content, process, product, and environment. The term 'process' refers to the activities students undertake in the classroom. Therefore, process differentiation refers to differences in students' classroom activities during learning, tailored to each student's individual needs. According to Rosyidah et al. (2023), differentiated learning can help students solve problems involving sound and light waves. Supporting factors for this success include increased motivation to learn because it aligns with each student's learning style. Furthermore, another supporting factor is the appropriateness of study groups to each student's abilities. Literature shows a correlation between differentiated science learning and problem-solving skills because, by tailoring learning experiences to individual student needs, educators can create an environment that encourages active engagement, critical thinking, and the application of scientific principles (Ramlawati et al., 2025; Zdilla, 2020)

This study aims to investigate the effect of the Teaching at Right Level (TaRL) approach based on process differentiation on eighth-grade students' problem-solving abilities. To do so, the following sub-questions are sought: Is there a statistically significant difference between students' pre-test and post-test problem-solving abilities in the experimental and control groups?

2. METHOD

2.1 Research Design

This study employed a quasi-experimental pre-test-post-test design (McMillan, 2000). Two classes were selected because both had the same average academic grade. They were then randomly assigned to either the experimental group or the control group. One of these classes served as the experimental group, in which students were taught about sustainable development using the TaRL-Process Differentiation approach. In contrast, the control groups received instruction based on the standard curriculum and textbook. Both groups were assessed for problem-solving skills before and after the treatment. Notably, the problem-solving skills in the experimental group were enhanced through the TaRL-Process Differentiation approach (Figure 1).

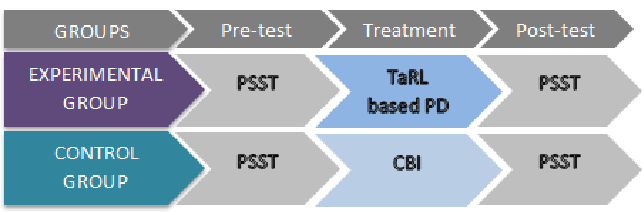

Figure 1 The experimental design of the research

2.2 Participants

The population in this study consisted of students in class VIII at SMPN 33 Makassar in the 2024/2025 academic year, comprising nine courses and a total of 275 students. The sample used in this study was selected using the Purposive Sampling technique, as the same educator teaches the chosen classes and has relatively similar learning outcomes (Fraenkel et al., 2012). The sample used was an experimental class, namely class VIII.F, and the control class, namely class VIII.G, each consisting of 30 students.

2.3 Data Collection Tools

The Problem-Solving Skills Test

The Problem Solving Skills Test (PSST) used is adapted from Polya (1978). There are four indicators designed to assess students' ability to solve problems related to the case. The indicators encompass various stages of problem-solving, including problem identification, strategy planning, strategy implementation, and solution evaluation. The PSST assessment was conducted using the Problem Solving Skills and Performance Assessment Rubric developed by Hamzah (2014). According to this rubric, the potential scores for each indicator per question are 2, 3, 2, and 3, respectively. To achieve a perfect score on this test, students must demonstrate strong abilities in several aspects of problem-solving. This includes recognizing problems, formulating a thorough strategy to address them, organizing information, analyzing data, and suggesting alternative solutions.

Treatment

The content on Waves and Vibration was taught using the TaRL-Based Process Differentiation approach in the experimental group classes, while the control group classes used Curriculum-Based Instruction (CBI). This topic, Waves and Vibration, was part of the 8th-grade curriculum. The study's first author prepared the applications for both the experimental and control groups.

Control Group

In the control group, students studied Vibrations and Waves through Curriculum-Based Instruction (CBI) over two weeks, comprising four lessons. During this time, they utilized videos that explained the basic concepts of vibrations and waves, photographs that illustrated real-life wave examples, and guiding questions for classroom discussions. The teacher employed an expository approach to examine in detail textbook examples of vibrations and waves. Group activities were organized around the applications of waves, such as in sound and light technologies. Students developed presentations on topics such as sound and electromagnetic waves, and their everyday applications. These presentations took various forms, including slides, posters, and displays, all grounded in the science textbook. In the subsequent weeks, the topic was emphasized through lectures, Q&A sessions, and discussions, focusing on wave phenomena.

Experimental Group

In the experimental groups, the TaRL-Based Process Differentiation approach was implemented over two weeks, comprising four lessons. During this period, students were given an ill-structured problem to solve collaboratively, with effective use of technology throughout the process.

Teaching at the Right Level

At this stage, students are given an initial assessment using two previously studied materials. The aim is to identify each student's cognitive abilities. Then, students will be grouped by cognitive level —low, medium, and high (Banerjee et al., 2017; Banerji & Chavan, 2016).

Process Differentiation

Differentiation strategies applied to various cognitive groups are presented in Table 1.

Each group will receive different treatment during the learning process. The learning steps for all levels are the same, but the guidance or assistance offered at each step differs. The Teaching at the Right Level (TaRL) approach, based on process differentiation, offers significant innovation in developing students' understanding of vibrations and waves. By focusing on individual ability levels, teachers can tailor instruction to each student's specific needs. For example, students who grasp the basic concepts of vibration more quickly can be given additional challenges, such as analyzing complex waves. In contrast, students who take longer can focus on understanding the basic concepts first with full teacher support. This

Table 1 Process differentiation strategies

Indicators	Cognitive Level Low	Medium	High
Stimulation	Provide by teacher	Provide by teacher	Provide by teacher
Problem statement	Provide by teacher	Provide by teacher	Provide by students
Data collection	Provide by teacher	Provide by teacher	Provide by students
Data Formulation	Provide by teacher	Provide by students	Provide by students
Verification	Provide by students	Provide by students	Provide by students
Conclusion	Provide by students	Provide by students	Provide by students

approach not only increases student engagement but also encourages them to think critically and creatively as they explore physical phenomena. Thus, students can develop better problem-solving skills, which are essential for facing scientific challenges in everyday life.

2.4 Learning Activity

Stimulation

Start with a thought-provoking problem or question that captures students' interest. This could be an open-ended question related to real-world scenarios. The teacher provides stimulus by presenting videos on vibrations and waves, then asks questions to explore the topic further.

Data Collection

Give students the freedom to explore the topic through hands-on activities, experiments, or research. This phase is crucial for fostering independent learning.

Data Formulation

Students actively engage in discussions and collaborate in small groups to solve problems. Each group member contributes their unique strengths, fostering a supportive learning environment where collective problem-solving leads to deeper insights and a more comprehensive grasp of the concepts being studied.

Verification

Students hold discussions to exchange information between groups by displaying their findings, which are then responded to by other groups, who may ask follow-up questions. Students adjust how they present their work to the learning level of each group.

Conclusion

Students conclude from their findings related to the concepts and formulas of vibrations and waves.

Students Outcomes

Figure 2 presents the results of one of the low cognitive-level groups in the experimental class, presented as student worksheets. This document reflects the students' understanding and creativity in completing the assigned tasks.

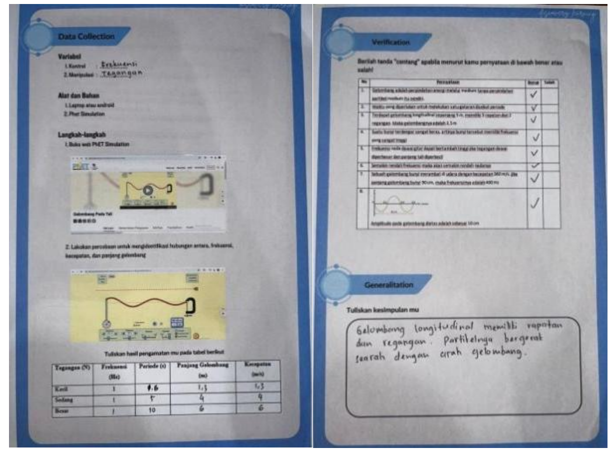

Figure 2 Worksheet

2.5 Data Analysis

The data gathered from the research is quantitative and will be analyzed using descriptive and inferential statistical methods. This data will be processed using the Statistical Package for the Social Sciences (SPSS) version 24.0 for Windows software.

The data from this study are quantitative. Furthermore, analyzed using the analysis techniques. Descriptive analysis is used to characterize students' problem-solving abilities. The descriptive statistics used include the lowest, highest, and average scores, as well as the variance and standard deviation.

After the pretest and posttest data are obtained, the data are processed to determine the average normalized N-Gain score and to assess the increase in problem-solving ability. Students. N-Gain analysis was also conducted using SPSS 24. The increase in students' problem-solving skills in the experimental class, as measured by the N-Gain test, was calculated using pretest and posttest data.

Inferential statistical analysis is employed to evaluate the research hypothesis using a t-test. Before hypothesis testing, normality and homogeneity tests are conducted.

The normality test is used to determine whether the data follow a normal distribution. Normally distributed data is essential for performing parametric hypothesis tests. In this study, the Shapiro-Wilk test was used to assess normality, with SPSS version 24.0 for Windows.

The criteria for testing normality are at a significance level of $\alpha = 0.05$ and degrees of freedom (dk) = $n - 1$, namely:

If the Shapiro-Wilk significance value is greater than 0.05, then the data are typically distributed.

If the Shapiro-Wilk significance value is < 0.05, the data are not normally distributed.

The homogeneity test assesses whether the data in this study exhibit equal variances (homogeneity of variance). This test serves as a guideline for subsequent statistical analyses. The homogeneity test is conducted using SPSS version 25.0 for Windows, following specific criteria:

If the significance value (Sig.) is less than 0.05, it indicates that the variances among two or more groups are not equal (not homogeneous). Conversely, if the significance value (Sig.) is greater than 0.05, it suggests that the groups have the same variance (homogeneous).

Statistical tests are used to determine whether the proposed hypotheses are true. Statistical tests can be performed if the sample data are approximately normally distributed. The hypothesis test used in this study is the Independent-Samples T-Test. This test is applicable when the samples are related to one another. Paired samples are from the same subjects who undergo two treatments: a pretest (before treatment) and a posttest (after treatment).

Meanwhile, the hypotheses used in this study include:

H1: There is an effect of the TaRL approach based on process differentiation on students' problem-solving abilities.

H0: There is no effect of the TaRL approach based on process differentiation on students' problem-solving abilities.

Hypothesis testing in this study was done by comparing the Sig. (2-tailed) value in the Independent Sample T-Test with the α value (0.05), with the following test criteria:

If the Sig. (2-tailed) value < 0.05 this indicates that the H0 (rejected) and H1 (accepted)

If the Sig. (2-tailed) value > 0.05 this indicates that the H0 (accepted) and H1 (rejected)

3. RESULT AND DISCUSSION

3.1 Descriptive Analysis

The results of the descriptive statistical analysis of problem-solving ability scores for students in the experimental and control classes are presented in Table 2.

Table 2 Descriptive statistical analysis

Descriptive Statistics	Experiment		Control	
	Pre	Post	Pre	Post
Sample Size	30	30	30	30
Ideal Score	100	100	100	100
Highest Score	50	91	37	78
Lowest Score	23	43	21	20
Mean	32.33	65.77	27.33	52.97
SD	6.01	13.88	4.18	15.75
Variance	36.16	192.66	17.47	248.309

Based on Table 2, the descriptive statistics indicate that the experimental group's average score is higher than the control group's. According to Naipospos and Simanjuntak (2025), TaRL can enhance problem-solving skills by allowing students to learn independently and actively, thereby improving their understanding of the concepts taught and facilitating more adaptive and meaningful learning.

The indicators of problem-solving ability assessed in this study encompass understanding the problem, strategizing, implementing the strategy, and reviewing the results. Based on the text results, the achievement of problem-solving ability indicators in the experimental and control classes is presented in Table 3.

Table 3 Compares indicator attainment (%) between groups

No	Problem Solving Ability Indicator	Percentage of Achievement			
		Exp (%)	Category	Ctrl (%)	Category
1	Understanding the Problem	85.22	Very high	83.33	Very high
2	Planning a Strategy	84.83	Very high	65.83	High
3	Implementing the Strategy	44.66	Moderate	29.22	Low
4	Evaluating	49.16	Moderate	30.16	Low
Average		65.96	High	52.13	Moderate

The results of the average analysis of students can be reviewed based on grouping in the learning process. Student learning groups are divided based on students' initial abilities.

In the first indicator — understanding the problem — the experimental class has a higher percentage of indicators than the control class. This happens because students taught using the TaRL approach play an active role and try to identify problems in the presented discourse, resulting in a higher indicator of student understanding than in the control class taught using the CBI.

Next, the second indicator is planning a solution. The percentage of indicators owned by the experimental class is higher than that of the control class. This happens because students in the experimental class are fully guided through the steps to solve problems based on the issues presented, so that, while working on the questions, they can plan their solutions effectively. After being guided and trained to break down the problem into problem-solving steps, students can work on the questions effectively.

The third indicator is solving problems. The experimental class has a higher percentage than the control class. During learning in the experimental class using the TaRL approach, students are fully guided in collecting data relevant to the problem, allowing them to work on questions, especially those related to the problem-solving indicator.

The last indicator is re-checking, in which the percentage of experimental class indicators is higher than that of the control class. In this indicator, students provide conclusions about the problem. Students in the experimental class are instructed to rephrase the results they have achieved.

Table 4 Analysis of problem-solving ability value acquisition based on cognitive level

No	Group	Cognitive	Experimental Class	
			Pretest	Posttest
1.	Group 1	Low	28	58
2.	Group 2	Medium	36	61
3.	Group 3	Medium	35	66
4.	Group 4	High	36	70
5.	Group 5	High	37	76

Based on the analysis results presented in Table 2, the highest percentage of indicator achievement is observed in the understanding of the problem indicator, specifically in the experimental class at 85.22% in the very high category and in the control class at 83.33% in the very high category. The lowest percentage of indicator achievement is in the 'Implementing the Strategy' indicator, specifically in the experimental class at 44.66 in the medium category and in the control class at 29.22 in the low category. The average achievement percentage for each indicator of students' problem-solving abilities in the experimental class is 65.96, categorized as high, and in the control class, 52.13, categorized as medium.

The average analysis of these students can be evaluated based on their groupings during the learning process, as shown in Table 4.

Students were grouped by cognitive level. At the low level, the teacher presented a problem, planned a procedure, and analyzed the results. At the medium level, the teacher presented a problem and planned a procedure, while the students studied the results. At the high level, the teacher presented only the issue, while the students carried out the planning procedure and analyzed the results. This aligns with Llewellyn's (2011) assertion that grouping was done homogeneously. The division of student learning groups was based on students' initial abilities, readiness, interests, and learning styles. The control class used CBI by dividing students into five heterogeneous groups.

3.2 N-Gain Analysis

N-Gain analysis was conducted to determine the extent of the increase in students' problem-solving abilities after implementing the TaRL approach and subsequently applying the CBI to enhance students' understanding of vibration and wave concepts. Data were collected following a pretest and posttest with students, as shown in Table 5.

Based on the analysis results presented in Table 5, 7 students in the experimental class received a high N-Gain score, whereas none in the control class did. Eighteen students received a medium N-Gain score in each class. Five students received a low N-Gain score in the experimental class, while 10 students received a low N-Gain score in the control class. This aligns with Widyastuti et al. (2024)'s view that TaRL provides more opportunities for students to actively participate in learning activities because they are grouped by ability level and given problems tailored to their achievement levels. Therefore, the learning activities implemented are tailored to each individual's needs.

Table 5 Percentage of N-Gain of students' problem-solving ability

Interval	Ctrl	Exp	Category
N-gain ≥ 0.7	0	7	High
0.3 ≤ N-gain < 0.7	18	18	Moderate
N-gain < 0.3	10	5	Low
G = 0.00	1	0	Not occur improvement
-1.00 ≤ g < 0.00	1	0	There was a decline

(Sukarelawan et al., 2024)

Table 6 N-Gain analysis of problem-solving ability based on cognitive level

Group	Cognitive	N-Gain Score	Category
Group 1	Low	0.40	Moderate
Group 2	Medium	0.54	Moderate
Group 3	Medium	0.50	Moderate
Group 4	High	0.37	Moderate
Group 5	High	0.63	Moderate

Next is the average N-Gain in problem-solving ability by cognitive level in the experimental class, presented in Table 6.

Based on Table 6, the N-Gain in the experimental class, grouped by students' cognitive level and process differentiation, was medium at each level. In group 1, with a low cognitive level, obtained an N-Gain score of 0.40, in group 2, with a medium cognitive level, obtained an N-Gain score of 0.54, in group 3, obtained an N-Gain score of 0.50, and in group 4, with a high cognitive level, obtained an N-Gain score of 0.37 and group 5 obtained an N-Gain score of 0.63. In general, the TaRL approach, based on process differentiation, increases students' problem-solving abilities at each level; however, group 5, with a high cognitive level, shows the most significant impact. These results are in line with research by Simbolon and Octariani (2024) that by implementing TaRL, students are allowed to learn at a level that suits their abilities, so that it can increase students' self-confidence, problem-solving abilities, and provide opportunities for students to be more independent in the inquiry process, which can improve their abilities more optimally (Ramlawati et al., 2025)

3.3 Inferential Statistics

The normality test was conducted on two classes: the experimental and the control. The data from both classes were post-test values. To test the normality of the experimental and control classes, the Shapiro-Wilk test was used with a significance level of > 0.05 in SPSS 25.0 for Windows. The results of the normality test for students' problem-solving abilities are presented in Table 7.

Based on Table 7, the Shapiro-Wilk test statistic, degrees of freedom (df), and p-value are obtained. Since

Table 8 Hypothesis testing of problem-solving ability using an independent sample t-test

Independent Samples Test									
	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Equal variances assumed	.744	.392	3.483	57	.001	13.413	3.851	5.702	21.123
Equal variances not assumed			3.492	56.386	.001	13.413	3.841	5.719	21.107

Table 7 Shapiro-Wilk normality test of problem-solving ability

Tests of Normality			
Class	Shapiro Wilk		
	Statistics	Df	Sig.
Experiment Pretest	0.941	30	0.100
Posttest Experiment	0.959	30	0.286
Pretest Control	0.944	30	0.118
Posttest Control	0.961	30	0.322

the significance values for the pretest and posttest exceed 0.05, it can be concluded that the data from both the pretest and posttest results are normally distributed.

Once both samples are confirmed to be normally distributed, the next step is to assess data homogeneity. The homogeneity test is conducted to determine whether the data in this study exhibits the same variance (homogeneous) or differs (heterogeneous). Based on the calculations for the experimental and control classes, a value of 0.436 is obtained, which exceeds the significance level of $\alpha = 0.05$. Therefore, the data are homogeneous.

The hypothesis test employed in this study is the Independent-Samples T-Test. This test is designed for samples that are not related to one another. The samples analyzed consist of data on students' problem-solving abilities before and after implementing the TaRL approach. The results of the hypothesis test for problem-solving skills using the Independent Sample T-Test are presented in Table 8.

The Independent Sample T-Test table shows that the Sig for problem-solving ability is 0.001. This means that H0 is rejected and H1 is accepted. It can be concluded that there is a significant increase in students' problem-solving skills after the application of the TaRL approach, based on process differentiation, in the experimental class and the CBI in the control class of vibration and wave material for class VIII at UPT SPF SMPN 33 Makassar.

4. CONCLUSION

TaRL, integrated with process differentiation in science learning, creates meaningful learning. It was found that there was a significant difference in students' problem-solving abilities when learning using the TaRL approach based on process differentiation compared to learning using instruction based on the standard curriculum and textbook. These findings suggest that the Teaching at the Right Level (TaRL) approach, based on process differentiation, can significantly enhance students' problem-solving abilities, particularly in abstract science topics such as vibrations and Waves. The observed moderate N-Gain and large effect size indicate that level-targeted instruction is an effective strategy for improving learning outcomes. This highlights the potential for broader application of TaRL in science education and supports the integration of differentiated teaching practices in classroom instruction. Limitations of this study include potential bias, as the sample is not random and relies on the researcher's judgment. This can limit the generalizability of research results, as the sample may not be representative of the broader population. Furthermore, subjectivity in determining selection criteria can undermine the research's validity. Future research could investigate the long-term effects of the TaRL approach across various scientific disciplines and diverse student populations.

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