Research Article

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The Collaboration of Teaching at The Right Level Approach with Problem-Based Learning Model

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Abstract: This study aims to explore the effectiveness of collaboration between the Teaching at the Right Level (TaRL) approach and the problem-based learning (PBL) model in improving student learning outcomes at junior high school and senior high school levels. TaRL is a method that emphasizes learning tailored to students' individual ability levels, while PBL focuses on PBL that encourages students to develop critical thinking and problem-solving skills independently. In this study, 73 students participated in two cycles of learning practices integrating the two approaches. The results of the initial diagnostic test were used to group students based on their ability levels, which were then followed by the implementation of learning using problem-based scenarios according to their groups. Quantitative data were obtained through learning outcome tests and analyzed using descriptive statistics and ANOVA. The mean value of students' final test results reached 79.73, indicating a significant increase in understanding after the implementation of this method. However, the ANOVA results showed that there was no significant difference between the tested groups, with a p-value of 0.662 and an F-statistic of 0.414. In addition, in-depth interviews were conducted to understand students' perceptions of the applied learning method. The results of the interviews revealed that students felt more engaged and motivated in the learning process, especially since the materials were tailored to their abilities and they were given the opportunity to solve problems relevant to real life. However, variations in learning outcomes were still evident, indicating the need for further adjustments in the approach to reduce performance disparities between students. This study concludes that the collaboration of TaRL and PBL can be an effective strategy for improving learning outcomes. However, adaptation and continuous monitoring are needed to ensure that all students can benefit the most from this approach.

Keywords: mathematics, problem-based learning, teaching at the right level

1 Introduction

The curriculum plays a crucial role in guiding learning in schools and educational institutions in Indonesia. As a central instrument in determining learning materials and teaching methods, its purpose is to create a quality education system that aligns with the demands of the times. The education curriculum in Indonesia has undergone several changes over time. Mathematics is an integral part of the education curriculum in Indonesia at all levels, from elementary to secondary and higher education. The National Council of Teachers of Mathematics (NCTM) is a professional organization that focuses on the development of mathematics education. NCTM consistently emphasizes the importance of understanding and applying mathematics in everyday life. They assert that mathematics helps students develop critical thinking, problem-solving skills, and communication abilities essential for daily life. Mathematics learning is essential at every education level because each level has a different material understanding level and different calculation formulas. Many abilities can be developed through mathematics learning, including developing critical, logical, systematic, and creative thinking levels. Most students find mathematics difficult because it is abstract with the correct answer (Yulianti & Gunawan, 2019). This is reinforced by Boaler (2016), who emphasizes the importance of understanding mathematics as a process of problem-solving and conceptual exploration, rather than merely pursuing correct answers. She argues that this approach can help reduce students' fear of mathematics and enhance their confidence. Fundamentally, mathematics aims to foster students' mindset to solve the problem, whether the problem is in the

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mathematics field or daily life problems. However, most students are not interested in learning mathematics because they perceive it as abstract.

The substance of mathematics learning is an interactive process between teacher and students that involves the development of thinking and processing logic in a learning environment intentionally created by the teacher with various methods so that mathematics learning activities are optimally developed (Mustafa, Amaluddin, Nurhaeda, Sari, & Jannah, 2023). Mathematics is taught to all students at every education level to equip them with logical, analytical, systematic, critical, creative thinking, and collaborative ability. These skills are needed to ensure that the students can obtain, manage, and utilize information to survive in ever-changing, uncertain, and competitive situations (Runisah, 2019).

Mathematics education should be well-designed to be enjoyable for students. Enjoyable mathematics learning refers to an instructional approach crafted to create positive, engaging, and motivating learning experiences for students to better grasp mathematical concepts. Fun mathematics learning aims to transform students' perceptions of mathematics from something difficult and dull into something interesting, relevant, and beneficial. Lockhart (2009), a mathematician, in his famous essay titled "A Mathematician's Lament," underscores the importance of understanding the beauty and joy of mathematics. He emphasizes that mathematics should be taught as a creative and enjoyable art. The teacher's role in the learning process is very instructive. Mathematics learning is the accumulation of teaching and learning concepts. Some characteristics of mathematics learning (Mustafa, Baharullah, & Sari, 2021) are (1) mathematics learning follows a spiral method; if learning a new concept, it is necessary to consider the concept or material learned previously. The new material is always related to the previous material. Repeating concepts in learning material by broadening and deepening is necessary for mathematics learning (spiral widening and rising). (2) Mathematics learning emphasizes deductive concepts. Mathematics is a deductive science that is organized in an axiomatic deductive way. However, in the learning process, an approach appropriate to the students' conditions should be chosen, for instance, following the intellectual development of the students.

Teaching mathematics needs learning theory-based, teachers' creativity, and students' readiness. The student's ability and readiness in the elementary, secondary, and higher levels differ. Therefore, the teachers are not only required to master the material but also master the appropriate technique in delivering the material. Mustafa et al. (2023) stated that in mathematics learning, the students are encouraged to get an understanding through experience of the shared and unshared nature of a set of objects (abstraction). Mathematics learning is sequential, in which mathematical concepts are taught sequentially from concrete to abstract, from simple to complex. It requires an innovative mathematics learning model that can activate students and enable their learning ability.

The problem identified in this research was the learning that was still teacher-centered. It impacts students' monotonous learning ability with low mathematics learning achievement. The indicator of success conducted is only on students' activity without considering the students' learning achievement. In Indonesia, learning achievement involves three domains, they are cognitive, affective, and psychomotor. The problem related to low mathematics learning achievement was found in research conducted by Nurbaeti (2019). In addition, similar problems were found in Paloloang (2014) and Surya (2017). If these problems are unattended, they will impact students' low mathematics learning achievement, lack of activeness in learning, and meaningless learning. Based on the problem, it is necessary to design innovative mathematics learning with a learning approach centered on students' readiness, not only at the grade level. Therefore, this research designed learning that collaborated the Teaching at the Right Level (TaRL) approach with the problem-based learning (PBL) model implemented in mathematics learning. TaRL approach can assist teachers in designing learning based on each student's achievement stage, especially in numeracy and literacy skills, while PBL is one of the innovative learning models that can provide an active learning condition (Mustafa, Sari, & Baharullah, 2019). PBL emphasizes real-world problem-solving, which can enhance the understanding of mathematical concepts and provide a real-life context for learning. Boaler (2016) explains that the PBL model can create situations where students can see practical applications of mathematical concepts, thereby improving their understanding.

This research aims to describe innovative mathematics learning collaborated TaRL approach with the PBL model, it was expected to improve the students' learning achievement, and the learning design contributed to improving the quality curriculum according to the requirement of Merdeka curriculum and was able to develop a quality generation. In mathematics learning, movement always occurs and aims to get something better. Hence, the more learning efforts are made, the more active changes so that the mathematics learning objective can be achieved. Mathematics learning objectives can be achieved by developing learning methods and learning strategies and organizing an appropriate learning design (Surya, 2017). It assists in developing students' potential so that the intended learning achievement can be optimized.

2 Literature Review

TaRL was first introduced by an Indian learning innovation organization. Later, other countries, including the United States, Zambia, Botswana, Ghana, Nigeria, Madagascar, and Uganda, developed this concept with different terms. According to Binaoui, Moubtassime, and Belfakir (2023), TaRL is a new trending remedial educational approach piloted in many countries. It matches pedagogical content to pupils' educational needs through various adapted activities after segmentation of pupils depending on their actual difficulties and needs. TaRL is part of a new paradigm of learning integrated with the Merdeka curriculum in Indonesia. Merdeka Curriculum is an innovation in Indonesian education aimed at developing students' potential and interests holistically. This curriculum provides freedom for students to choose their learning interests, reduces academic burdens, and encourages teacher creativity. The implementation aspects of the Merdeka Curriculum include a commitment to basic learning, support for teaching skills, targeting specific groups, and utilizing technology to enhance and expedite progress.

New paradigm learning ensures that learning activities are student-centered. According to this new paradigm, learning is a cycle that begins with standard competency mapping, planning the learning process, and conducting assessments to improve learning so students can achieve the intended competencies. New paradigm learning enables teachers to formulate learning designs and assessments based on students' characteristics and needs. TaRL can generate student-centered learning by implementing the Indonesian education philosophy (Ki Hajar Dewantara philosophy).

TaRL is a learning that considers students' capacity and interest needs (Ningrum, Juwono, & Sucahyo, 2023). TaRL does not begin without first assessing to determine pupils' current learning levels (Adigun, 2021). TaRL's approach emphasizes that teaching should start at the level of the student and focuses on helping students gain foundational reading, understanding, and expressing as well as arithmetic skills which are the building blocks for moving students forward. TaRL also groups students by learning level, thus allowing teachers to focus on helping students learn foundations. TaRL segmentation of pupils is carried out by ability rather than age and grade (cross-grade segmentation). In Pakistan, 20,800 pupils across 530 schools in three provinces of Pakistan were exposed to a 45–60-day learning camp where they received remedial education based on TaRL (Binaoui et al., 2023). Implementing the TaRL approach requires teachers to conduct pre-assess as students' diagnostic tests to identify students' characteristics, needs, and potential so that the teacher obtains preliminary skills and development of students (Suharyani, Suarti, & Astuti, 2023). The stages of TaRL implementation are explained in Figure 1.

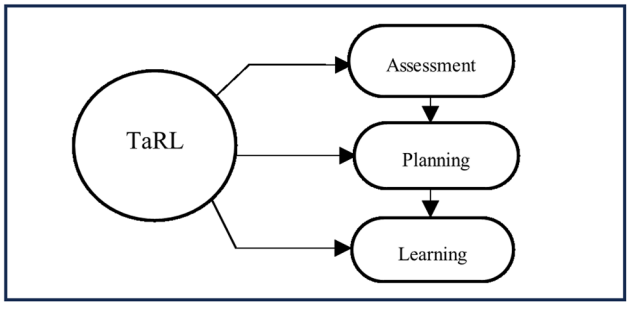

Figure 1: The stages of TaRL implementation.

In implementing the TaRL concept, the teacher must first conduct an assessment. This assessment aims to identify students' characteristics, potential, and needs so that the teacher is informed of the student's developmental stages and learning achievements. Second, the planning step. After obtaining the assessment result, the teacher can organize the planning of the appropriate learning process. For instance, what kind of learning resources are used, the method, and the grouping of students according to the ability level. Thirdly, the learning step. In the learning step, the teacher needs to conduct periodical assessments to determine the developmental process that the students have achieved. In addition, the evaluation at the end of the learning process is also crucial. It aims to determine the achievement of the learning objective and assist the teacher in designing the following learning.

Implementing the TaRL approach in this research collaborates with the PBL model. The reason for choosing the PBL model is that it is assumed to improve students' learning activities and academic achievement, assist students in solving problems through direct experience in learning, and increase their ability to solve new or actual problems. PBL is one of the innovative learning models that can provide active learning conditions to learners (Mustafa et al., 2019). According to Laine and Mahmud (2022), PBL is one of the approaches that is believed can help in improving students' thinking skills and thus improve students' twenty-first-century learning skills. PBL is a teaching strategy believed to improve students' twenty-first-century learning skills, especially high-order thinking skills. This situation is evident as PBL is believed to help improve students' critical thinking skills (Aliyu, 2019) and increase students' motivation in problem-solving (Suwono & Dewi, 2019). The PBL model can put students as the center of learning that

requires complete activities of students to solve every problem they face independently through constructing their knowledge and understanding.

Implementing PBL requires students to think critically to solve a problem related to them given by teachers. Considering this, PBL influences students' thinking skills, especially critical thinking (Arifin, Setyosari, Sa'dijah, & Kuswandi, 2020; Prabawanto & Susilo, 2020). The PBL model is a student-centered learning model that derives from the concrete problem as the main context in the learning process for students to think critically to solve a problem (Rahmadani, 2019). The PBL model is designed to assist students in developing their thinking and problem-solving skills, learn the adult role, and become independent students. The PBL also helps students develop their problem-solving skills, which are essential in the real world as they face complex and unpredictable problems (Smith et al., 2022). Students work in small groups to research the problem and develop a solution, with guidance and support from their teacher. The teacher acts as a facilitator rather than a lecturer and provides feedback and guidance to students throughout the process.

The PBL model, in its implementation, raises a problem as the first step in gaining and integrating new insights (Dahlia, 2022). The characteristics of the PBL model are implementing contextual learning, the problem presented can motivate students to learn, integrity learning is motivated learning with the unlimited problem, the students are actively involved in the learning, collaborative work, and students have various skills, experiences, and concepts. The stages of the PBL model, specifically in mathematics learning conducted as follows (Mustafa et al., 2019) (Figure 2).

Implementing PBL encourages students to find solutions to problems through discussion in pairs or groups. Thus, communication and teamwork skills can indeed be improved through implementing PBL (Laine & Mahmud, 2022). Teaching materials based on PBL can be used as one of the teaching materials for students (Lesilolo, 2023). PBL involves presenting students with a real-world problem or scenario that requires them to apply their knowledge and skills to develop a solution (Hadibarata, Hidayat, & Kwabena, 2023).

The collaboration of TaRL with the PBL model in this research aims to assist students in fulfilling their learning needs, thinking critically, improving their learning ability, and solving problems so that their mathematics learning achievement improves the implementation of the collaboration of TaRL and PBL model in mathematics learning conducted in the following.

The collaboration of the TaRL approach with the PBL model in mathematics learning can accommodate each student's differentiated ability. The students were grouped based on their development or ability level so that they could actively participate in the learning process and improve their cognitive. In addition, the learning design will assist students to gain knowledge and improve their ability in literacy and numeracy so that in the next grade, the students can follow learning well and not have the same difficulties.

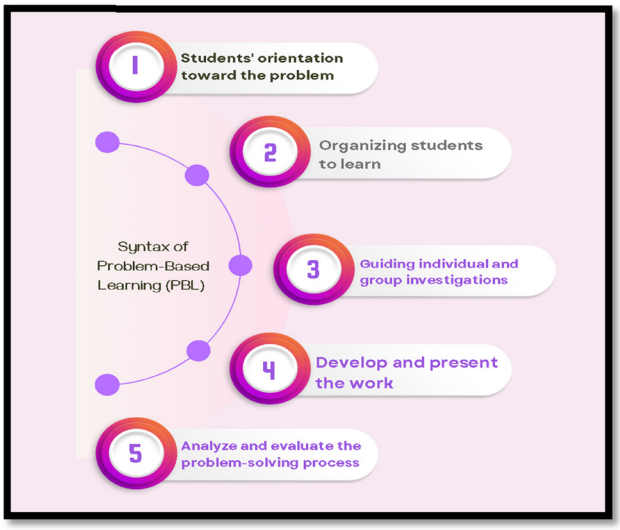

Figure 2: Syntax of PBL model (Mustafa et al., 2019).

3 Research Method

3.1 Research Design

This research is a mixed methods approach. According to Creswell (2012), mixed methods involve combining quantitative and qualitative research methods. The purpose is to better understand the research problem by integrating quantitative numbers and qualitative descriptive details. An Explanatory Sequential Design is utilized in this research. It starts with quantitative data collection and analysis, then moves on to qualitative data collection and analysis. The main goal is to explain or enhance the results from quantitative analysis with qualitative data.

3.2 Participants

This study involved a total of 73 students from junior high school and senior high school who were selected as research subjects. The research subjects consisted of students from three different classes in two purposively selected schools. The selection of schools and classes was based on compliance with certain criteria, including the school's willingness

to participate, the diversity of students' academic backgrounds, as well as the availability of teachers who support the implementation of the learning model tested in this study. The students participating in this study have diverse backgrounds in terms of academic achievement, learning motivation, as well as access to learning resources at home. This variability was considered to understand how the TaRL approach and PBL model can be adapted for different learning contexts and different groups of students. The selection of 73 subjects was done to increase the reliability and generalizability of the research results. With a larger sample size, this study aims to obtain more representative results and detect significant effects of implementing the TaRL and PBL approaches in mathematics learning. Researchers use this technique aiming to obtain sample criteria truly in accordance with the research to be conducted, namely the school being easily reachable by the research team, students at the school having diverse backgrounds and abilities, generally being communicative, the school being open to receiving information and novelty in learning development, and implementing a Merdeka Curriculum. The Merdeka Curriculum refers to various educational concepts and policies implemented in Indonesia after 2022. The curriculum in Indonesia continues to evolve and adjust to improve the quality of education. Some of the principles associated with the concept of a Merdeka Curriculum in Indonesia involve emphasizing a more independent, creative approach to learning and giving students more freedom to determine their learning path. A shift in focus from curricular learning (following a strict curriculum) to learning that prioritizes the development of individual abilities and the active involvement of students in the learning process.

3.3 Data Collection

Data collection techniques in this study used observation, tests (diagnostic and final tests), and, if necessary, interviews. The data analyzed were obtained from observations and tests. The test instrument was prepared based on a grid that was adjusted to the learning outcome indicators and Bloom's Taxonomy in the cognitive domain of secondary school students. The questions that became instruments were in the form of descriptions (essays).

3.4 Data Analysis

The data obtained from this study were analyzed using quantitative and qualitative approaches to provide a comprehensive understanding of the effectiveness of the collaboration of the TaRL approach with the PBL model.

3.4.1 Quantitative Analysis

Quantitative data were obtained from essay test scores given to students from three different classes. The test was designed to measure the understanding of mathematical concepts after applying the learning model. The test scores were analyzed using descriptive statistics to describe the distribution, mean, median, and standard deviation of the students' scores. To determine the significance of the differences between learning outcomes in the various classes, inferential statistical tests were used. These tests will identify whether there is a significant difference between the different groups in terms of mathematical understanding after applying TaRL and PBL. Additionally, as the research subjects came from three different classes, ANOVA was used to evaluate the difference in test scores between these groups.

3.4.2 Qualitative Analysis

Qualitative data were collected through observations during the learning process. These observations included students' interactions in groups, how they solved problems, as well as their responses to the applied learning approach. The observation data were thematically analyzed to identify common patterns and emerging findings in students' behavior, the learning strategies they used, as well as the challenges faced during the learning. To ensure the validity and reliability of the qualitative findings, data triangulation will be conducted by comparing the observation results with the quantitative data from the essay test. This aims to identify the congruence between quantitatively measured learning outcomes and qualitatively observed learning patterns.

3.4.3 Interpretation and Discussion

After conducting quantitative and qualitative analysis, the results will be interpreted to evaluate the effectiveness of the TaRL and PBL approaches. The interpretation will consider the academic background of the students, the class characteristics, and the learning context in each school. The discussion will focus on the implications of these findings for classroom practice and the potential for wider application in the context of mathematics education. Using a combination of quantitative and qualitative analysis, this research aims to

Table 1: Design of the implementation stage of the TaRL approach and PBL model

Learning stages	Learning activities
Assessment	At the beginning of the learning process, the teacher conducted an assessment to determine students' potential, characteristics, needs, and development. According to the assessment result, the students will be grouped based on their achievement level and similar abilities **Stage 1: Students' orientation toward the problem:** 1. The teacher presents a problem that will be solved in the group. The problem should be contextualized. Students can raise the problem through reading materials or worksheets 2. The students observe and understand problems that the teacher presents, or they gain from the reading materials suggested. In this stage, the students will be grouped based on diagnostic assessment results
Planning	At this stage, the teacher is allowed to design various learning activities using various learning instruments so that they can be adjusted to students' achievement levels and abilities regardless of their age and grade level **Stage 2: Organizing students to learn** 1. The teacher conducted the learning process by grouping students based on the students' diagnostic assessment completed at the beginning. The teacher differentiates assignments for each group based on students' diagnostic test results 2. The teacher ensures that each group member understands their assignment 3. Students are grouped based on their ability level and will discuss in their respective groups based on the problems to be solved
Learning	In the learning process, the teachers have to focus on developing students' achievement levels and essential abilities by conducting periodic assessments that can be conducted with various activities **Stage 3: Guiding individual and group investigations** 1. The students discussed and shared assignments to find data/materials/instruments needed to solve problems in their respective groups 2. The teacher controls students' involvement in collecting data/materials during the investigation 3. Students conduct investigations (find out data/references/sources) for group discussion **Stage 4: Develop and present the work** 1. The teacher monitors discussion and guides the students to compile reports so that students can present their work 2. The group discusses finding the problem-solving solution, and the result is presented in a project **Stage 5: Analyze and evaluate the problem-solving process** 1. The teachers guide the presentation and motivate the group to appreciate and give suggestions to another group. The teacher, together with students, concludes the material 2. Each group presented their project, and the other group appreciated them. The activity is continued by summarizing/concluding based on the suggestions obtained from other groups

provide a comprehensive picture of the effectiveness of the implemented learning model, as well as to understand how students respond and thrive in a collaborative and PBL environment.

Descriptive statistical analysis was used to determine the students' mathematics achievement using the following categorization.

Using a combination of quantitative and qualitative analysis, this research aims to provide a comprehensive picture of the effectiveness of the implemented learning model, as well as understanding how students respond and thrive in a collaborative and PBL environment.

4 Result

The research was conducted in two learning practice trials (two learning cycles) in the classroom. Each learning practice cycle lasted 80–90 min, so the total learning practice trials were 160–180 min. The learning syntax followed each stage of the PBL model, collaborating with TaRL. Observations of the learning process were made based on the learning indicators at each stage of TaRL and PBL, as described in Table 1. To deepen the observations more thoroughly, each trial of learning practices was documented (Table 2).

At the initial stage, diagnostic tests were given to students. This assessment is an effort to obtain information about the condition of students, both from the cognitive aspect related to their readiness to receive subject matter. The diagnostic results are used to group students based on their ability level. This is important because it is related to student involvement during the learning process and the efforts that teachers will make so that students achieve learning completeness. Data on student diagnostic test results are presented as follows (Table 3).

The average score of all the data was 66.75. This indicates that overall, students' performance in the diagnostic test was moderate. The average score gives a general idea of the students' level of understanding collectively. However, as this average score can also be affected by very high or very low scores (outliers) obtained by students. The median of the data above is 73, which is higher than the mean of 66.75. This value indicates that there were some lower scores that pulled the average down, but most students scored above the average. Furthermore, the standard deviation of 15.72 shows that students' scores varied quite a lot around the mean of 66.75. The higher standard deviation indicates that there is significant variation in students' test results, as some students have scores that are much higher and lower than the average.

The results of this analysis show that there is significant variation in students' abilities, with most students scoring relatively well (above the median). However, some students with lower scores may require further attention or additional support in learning to ensure that they can reach their full potential. The results of this diagnostic test provide important insights into students' readiness and abilities, which are then used to design more effective and targeted follow-up learning.

4.1 Quantitative Data Analysis

4.1.1 Statistical Description of Student Scores

This study involved 73 students from three different classes in two purposively selected schools. These students were given essay tests to measure their understanding of mathematical concepts after learning with the TaRL approach and PBL model. The results of descriptive statistical analysis are shown in Table 4.

The average student score in this study was 79.73. This shows that overall, students performed quite well in the essay test designed to measure their understanding of the mathematical concepts taught. The median of the students' scores was 79.0, which is very close to the mean. This indicates that the distribution of scores was relatively symmetrical, with most students scoring around this median. The standard deviation was 9.61. This value indicates the degree of dispersion of students' scores around the mean. With this standard deviation, we can say that most students' scores range from 70.12 to 89.34, which is within one standard deviation of the mean. This spread indicates that there is variation in students' understanding of the material taught, although the variation is not very large.

Furthermore, the distribution of these scores is illustrated through histograms and box plots, which show an even distribution of scores without any significant outliers (Figure 3).

The distribution of student scores displayed in the histogram shows that student scores are spread fairly evenly, with the peak of the distribution around the mean value. This indicates that no class is conspicuously better or worse than the others, with most students achieving scores around the mean. The boxplot visualization confirms that the median score is close to the mean, and there are no significant outliers in the data. This indicates that there are no students whose learning outcomes are drastically different from the majority of other students.

4.1.2 ANOVA

Overall, the descriptive data show that most students have a good understanding of the mathematics material taught using the TaRL and PBL approaches. There are no significant differences between students from the different classes, which is reflected in the fairly even and consistent distribution of scores across the groups. This analysis provides a

Table 2: Standard category of students' learning achievement

Score	Category
86–100	Very high
76–85	High
66–75	Moderate
46–65	Low
0–45	Very low

Table 3: Diagnostic test descriptive statistics

Statistics	Value
Average (mean)	66.75
Median	73
Standard deviation	15.72

Table 4: Descriptive statistics of the final test

Statistics	Value
Average (mean)	79.73
Median	79.0
Standard deviation	9.61

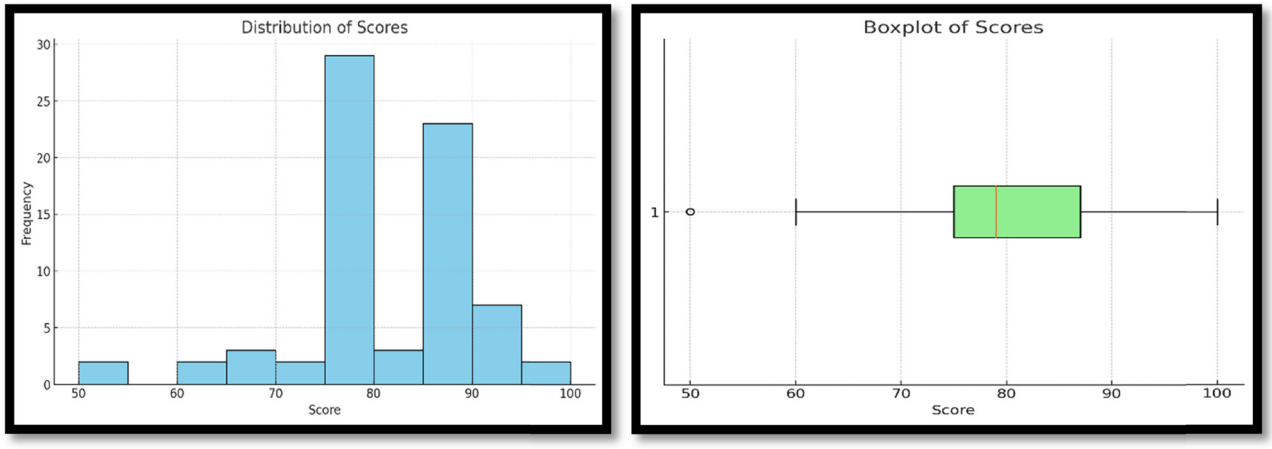

Figure 3: Distribution of student learning outcomes score.

strong basis to proceed with further inferential analysis, namely ANOVA, to evaluate the differences between the grade groups in more depth. The results of the ANOVA are shown in Table 5.

- ***F*-statistic**: 0.414 indicates that the variation between classes is relatively small compared to the variation within classes.
- ***p*-Value (PR(>*F*))**: 0.662, which is well above the typical significance level (e.g., 0.05), indicates that there is no statistically significant difference between the mean scores in the three classes.

The ANOVA results show an *F*-statistic of 0.414 and a *p*-value of 0.662. The *p*-value, which is well above 0.05, indicates that there is no statistically significant difference between the mean scores of students in the three classes. Thus, it can be concluded that the application of the TaRL and PBL approaches resulted in relatively uniform achievement across all classes, with no one class being significantly better or worse than the other. Therefore, the *p*-value of 0.662 indicates that there is no statistically significant difference between the average scores of students in the three classes. In other words, based on these data, we cannot conclude that there is a significant difference in math learning outcomes among the three classes using the TaRL and PBL approaches.

4.2 Qualitative Data Analysis

4.2.1 Observation During Learning

Qualitative data were obtained through observation during the learning process. These observations focused on students' interactions in groups, how they solved problems, as well as their responses to the applied learning approach. The next activity is conducted learning based on the planning organized (Figure 4).

At this stage, the teacher presented problems to students (relevant problems were also revealed from students' experiences). At this stage, the teacher explains the learning objective, describes the logistics required, motivates students to engage in problem-solving activities and proposed problems, and motivates all students to be actively involved during the learning process. In the next activity, the students were grouped according to the student's ability category based on the diagnostic test results. The students were grouped into five groups, each consisting of 5 or 6 (Figure 5).

At this stage, the teacher facilitated students to define and organize the task related to the problem. The teacher will intensively provide assistance and guidance for students in the Low Category (LC). There are three groups in the LC, one group in the Medium Category (MC), and one group in the High Category (HC). The teacher ensured that

Table 5: ANOVA

Source of variation	Sum of squares (sum_sq)	Degrees of freedom (df)	*F*-statistic (*F*)	*p*-Value (PR(>*F*))
Class	77.85	2	0.414	0.662
Residuals	6575.19	70	0	0

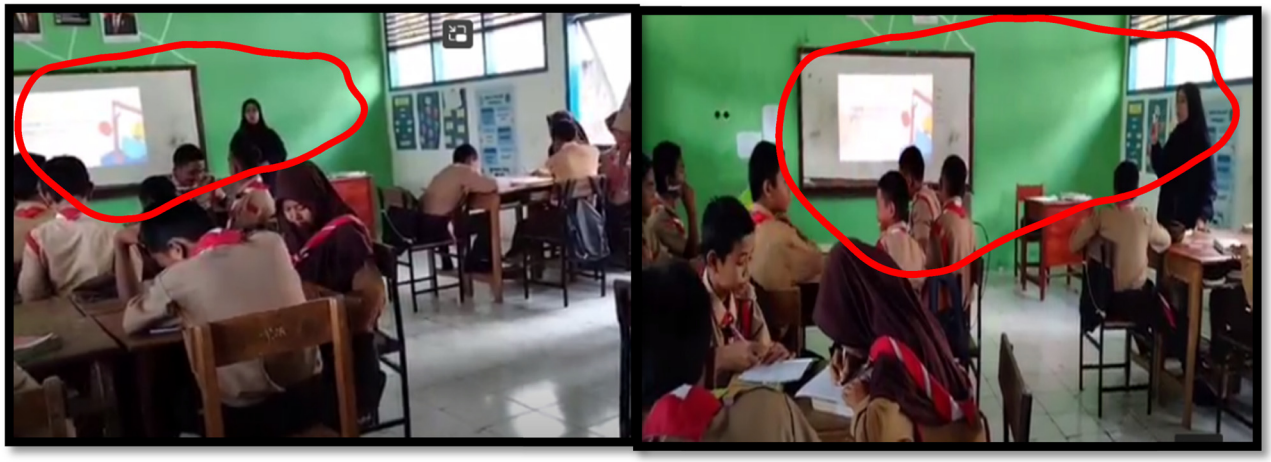

Figure 4: Students' orientation toward the problem.

each group, especially in LC, could understand the problem well and recognize what should be conducted to solve the problem.

In the next activity, the teacher facilitated to encouraged students to collect appropriate information and conducted experiments to obtain explanations and problem-solving in their groups. Specifically, the assistance to the LC was intensively conducted. At the same time, groups with the MC and HC were given the flexibility to discuss each other and proposed ideas in their groups, and HC would be given challenges to solve problems from different perspectives at different levels (Figure 6).

At this stage, the teacher facilitated students in planning and preparing the project results for each group. The project results were presented in front of other groups and discussed among groups so that various suggestions and ideas from other students were obtained, information exchanged, peer learning and working together in solving problems, and students presented the solution found (Figure 7).

At this stage, the teacher facilitated students to reflect and evaluate the process and the result of the investigation. The students were assisted in evaluating the related learning activities. It included the knowledge obtained by students and each student's role in the group.

Some of the findings from these observations are as follows:

(1) Student Collaboration: Students tend to work well together in groups, demonstrating the ability to share ideas and strategies when facing math problems. TaRL and PBL seem to be effective in encouraging students to think critically and find solutions through group discussions.
(2) Adaptation to Learning: The TaRL approach helps in grouping students based on their level of understanding,

Figure 5: Organizing students to learn.

Figure 6: Developing and presenting the work.

so that each student can receive a challenge that suits his or her ability. This facilitates more effective learning, especially for students who may struggle to keep up at the same pace as their peers.

(3) Positive Response to Learning Methods: Most students showed a positive response to the combination of TaRL and PBL approaches. They feel more engaged and motivated in learning mathematics, as this approach gives them the opportunity to actively solve problems and apply the concepts learned.

The results of observations of student activities of the two learning practices using TaRL and PBL are shown in Table 6.

The data show the results of two learning practices conducted with the TaRL approach, collaborated with the PBL model, on 73 subjects. The average (mean) score achieved by the subjects in the first learning practice was 74.41, while in the second learning practice, it increased to 76.41. This increase in the mean indicates that there was a slight improvement in the learning outcomes when the subjects took part in the second practice, which could be indicated as a result of adaptation or increased student understanding of the applied method. In both learning practices, the minimum score obtained by the subjects also showed a significant difference. In the first learning practice, the minimum score was 50, while in the second practice, the minimum score increased to 65. This indicates that the approach applied in the second practice succeeded in raising the students' comprehension base, which was previously below 65, to a higher level. This could mean that the strategies used in the second practice were more effective

Figure 7: Analyzing and evaluating the problem-solving process.

Table 6: Recapitulation of learning practices

Aspect	Learning practice 1	Learning practice 2
N	73	73
Mean	74.41	76.41
Minimum score	50	65
Maximum score	100	100
Std	28.84	29.29

in reaching students who had difficulties in understanding the material. Although the maximum score remained the same in both practices at 100, this suggests that there was consistency in the peak ability achieved by the best students. However, the variation in the standard deviation (Std) between the two practices shows that the distribution of scores among students was slightly more even in the first practice (Std 28.84) compared to the second practice (Std 29.29). This could indicate that while there was an increase in the mean score and an increase in the minimum score in the second practice, there was also an increase in the variation in student performance. These data reflect that the collaboration between TaRL and PBL approaches had a positive impact on student learning outcomes. The increase in the mean and minimum scores indicates that the teaching strategies implemented helped students in understanding and applying the material better. However, the larger variation in standard deviation in the second practice may require further attention to ensure that all students can benefit the most from this learning method, reducing performance disparities among them.

4.2.2 Findings from Thematic Analysis

The thematic analysis of the observation data revealed some key themes that emerged in student behavior and the effectiveness of the approaches applied:

(1) Active Engagement: Students are more actively engaged in learning, especially when working in groups to solve problems.
(2) Improved Concept Understanding: Students who previously had difficulty with certain concepts showed improvement in their understanding after receiving personalized learning.
(3) Challenges in Implementation: Some of the challenges encountered during implementation included the need for further adjustments to a very heterogeneous group of students in terms of ability, as well as the need for further training for teachers in implementing this learning model effectively.

Interviews with teachers provided insights into the effectiveness of TaRL and PBL implemented. Teachers observed that TaRL helped them teach more effectively, as they could tailor the materials to individual students' needs.

5 Discussion

The TaRL approach and PBL model collaboration in this research were trialed twice. It was considered to evaluate the weaknesses and the strengths of the collaboration. Accurate data can be obtained and can be recommended for improving the quality of learning.

The result of the research showed that the collaboration of the TaRL approach with the PBL model effectively improved learning achievement. Each stage of learning that has been formulated in the collaboration is conducted according to the procedure to achieve the learning objectives. The stage of student orientation on problems aims to explain the learning objective and is a process to motivate students to learn. This stage can facilitate students to associate their prior knowledge with the new topic they will learn. The stage of organizing students in learning facilitated students to determine and organize learning assignments related to the provided problem. Students' involvement in the learning process makes the classroom atmosphere more active and can improve students' collaboration. The stage of guiding the individual or group investigation encourages students to obtain appropriate information, conduct experiments, and find explanations and solutions. This activity is beneficial for students to improve the means of the learning process. Meaningful learning is the type that associates students' activities with daily life experiences. The stage of developing and presenting the results facilitates students to plan and prepare their project results as reports appropriately. This activity fosters independence and responsibility and increases students' confidence to make learning more student-centered. Analyzing and evaluating the problem-solving process helps students to reflect on the investigations and processes they apply. This activity can provide students with correct learning concepts according to their characteristics.

The characteristic of implementing the collaboration TaRL approach with the PBL model is cognitive diagnostic assessment (CDA). Diagnostic assessment is a Merdeka curriculum assessment explicitly conducted to identify characteristics, conditions of competence, strengths, and weaknesses of students' learning model. The assessment's

strengths were providing preliminary information about students' learning needs, the mastery level of the material, the weakness and materials unit that students have not mastered, and the level of students' understanding to allow the teacher to predict students' success during the summative assessment. The main point of the assessment is to gain preliminary information related to students' condition. It was supported by Firmanzah and Sudibyo (2021) that assessment is an activity to gain information to increase clarity in making different decisions.

Cognitive diagnosis assessment can be conducted regularly, at the beginning when the teacher will introduce a new learning topic, at the end when the teacher has finished explaining and discussing a specific topic, and other times during the semester (every 2 weeks/months/quarter/semester). The abilities and the skills of students in the class are different. Some students understand specific topics more rapidly, but others take longer to understand the topic. A student who understands rapidly in one topic does not certainly understand rapidly in other topics. Specifically, CDA is designed to measure specific knowledge structures and processing skills in students to provide information about their cognitive strengths and weaknesses. The assessment provides feedback for the teachers, rendering it demanding to find and present appropriate feedback, and whatever bridges the educational demands and real-world requirements are assessment tools (Panahi & Mohebbi, 2022).

Grouping is the other characteristic of the collaboration between the TaRL approach with the PBL model. The grouping in this collaboration results from a diagnostic assessment conducted at the specifically homogeneous beginning. The strengths are that the students will get treatment based on their learning needs, learning ability characteristics, and cognitive level. Therefore, the students can develop themselves, explore their abilities, and give feedback on their learning achievement to achieve the intended learning completeness. This grouping is based on the differentiated instruction concept, which attempts to adjust the learning process by providing various ways through differentiating content, process, product, and learning environment, and preliminary assessment to fulfill the individual learning need. It was supported by Liou, Cheng, Chu, Chang, and Liu (2023) that differentiated instruction increased students' learning interests, promoted focused and independent thinking, and enhanced academic achievement.

The collaboration between the TaRL approach and the PBL model makes student actively involved and student-centered learning to improve students' cognitive ability. This result emphasizes the importance of implementing innovative learning models because it will facilitate students to encourage knowledge and improve the ability of literacy and numeracy. Therefore, the students can participate appropriately in the next class without facing the same difficulties. TaRL learning does not aim to prevent high-ability students from learning more. However, the main requirement of a teacher ensures that all students can achieve the same minimum standards. Considering different preliminary competencies, the TaRL approach is the appropriate solution to solve the problem of different student competence in participating learning programs.

The implementation of TaRL is conducted by diagnosing students' competence and basic competence (diagnostic test). The diagnostic test results were used as the basis for students grouping according to their level. At level 1, in the classroom, the TaRL approach is begun by testing students with superficial level questions. The test result is then used as the basis for students' grouping, not based on class and age. After that, the teacher designs various exciting learning activities to motivate students to improve their learning. The TaRL approach has been proven effective in enhancing students' learning ability and completeness. An increase in learning completeness was observed between Learning practice 1 and Learning practice 2. However, despite the rise in average and minimum scores, learning completeness has not been evenly distributed among all students, as indicated by the high standard deviation. This suggests that while some students have attained learning completeness, there are still groups requiring more attention to reach the same level. Therefore, to achieve greater overall learning completeness, targeted learning strategies and possibly special interventions are necessary for students below the completeness standard. Individualized approaches and differentiated learning can serve as solutions to address this disparity and ensure all students meet expected learning outcomes.

Based on the design of the TaRL approach and PBL model stage (Table 1) and the research result analysis conducted through direct implementation by practical learning, it can be formulated as a new finding for implementing collaboration between the TaRL approach and PBL model (Table 7).

The TaRL approach is part of the new learning paradigm, while the PBL model is an innovative learning model problem-based. Both emphasize student-centered learning, learning that fulfills diverse potentials, need and learning stages, and interest of students. Data analysis of the research result has proven that collaboration effectively improves students' learning ability and completeness. Their collaboration contributes to improving the learning quality as the requirement of the Merdeka Curriculum. In addition, it can foster a quality generation because its implementation includes cognitive, affective, and

Table 7: Stage of the implementation of the TaRL approach with the PBL model

Learning stage	Learning activities	Learning objective
Assessment	At the beginning of the learning process, the teacher conducts an assessment to determine students' potential, characteristics, needs, and development. According to the result assessment, the students will be grouped based on their achievement and ability level	This assessment facilitates the teacher to identify the understanding level and ability of the students individually
	Stage 1: Students' orientation toward the problem 1. The teacher presents the problem to be solved in groups. The problem should be contextualized. The students themselves can identify the problem through reading materials or worksheets 2. The students observe and understand the problem presented by the teacher, or they identify it from the reading materials suggested. The students will be grouped based on the diagnostic assessment result at this stage.	This activity directs student-centered learning and encourages learning motivation
Planning	At this stage, the teacher is flexible to design various learning activities through various learning instruments so that learning activities can be adjusted to the achievement level and the student's ability, not just their age and grade level	Grouping according to the achievement level enables teachers to provide instruction that is appropriate for students' needs
	Stage 2: Organizing students to learn 1. The teacher conducts learning by grouping students according to the diagnostic assessment conducted at the beginning. Based on the diagnostic assessment result, the teacher can differentiate students' assignments for each group 2. The teacher ensures that each group member understands their assignment 3. The students are grouped based on their ability level and discussed in their group based on the problem that will be solved	1. This activity will develop students' social and communication skills that allow them to learn and work in a team 2. Problem-based learning allows students to apply the understanding and skills they learn in a real context. It facilitates students to understand the relevance and practical application they learned
Learning	In the learning process, the teacher must consider students' achievement and basic-level progress by conducting periodic assessments that can be organized into various activities	This stage encourages the collaboration of teachers in learning. It is crucial to measure students' progress continuously
	Stage 3: Guiding individual and group investigations 1. Students discuss and divide tasks to find the data/materials/tools needed to solve the problem in their respective groups 2. The teacher controls students' involvement in collecting data/material during the investigation process 3. The students investigate (find data/references/sources) for group discussion	The teacher gives constructive feedback and guidance to each student to facilitate them in improving their understanding and skills
	Stage 4: Develop and present the work 1. The teacher monitors discussion and guides the report-making to prepare each group for presentation 2. Groups discuss to formulate problem-solving solutions, and the result is presented in the project	
	Stage 5: Analyze and evaluate the problem-solving process 1. The teacher guides the presentation and motivates other groups to appreciate and give feedback to other groups. The teacher and students conclude the material 2. Each group conducts a presentation, and other groups will appreciate them. The activity continues by summarizing/making conclusions according to the input obtained from other groups	

psychomotor abilities so that the learning achievement assessment is appropriate with the objective equitably, objectively, and educationally.

6 Conclusion

This study examines the effectiveness of collaboration between the TaRL approach and the PBL model in improving student learning outcomes at the basic education level. Based on the results of quantitative and qualitative data analysis, it can be concluded that the application of the TaRL and PBL combination has a positive impact on students' understanding of the subject matter. Test results showed that students' final average score reached 79.73, indicating an increase in understanding after the application of this learning method. Although the ANOVA showed that there was no significant difference between the groups of students tested, interviews with students revealed that this approach successfully increased their engagement and motivation in learning, especially since the material was tailored to individual ability levels and relevant to real-world problems. However, the study also found that variations in learning outcomes between students still occurred, indicating the need for further adjustments in the application of this method to ensure equitable benefits for all students. A more flexible approach and stricter monitoring may be needed to address these disparities. The collaboration between TaRL and PBL proved to be an effective learning strategy, however, to achieve the full potential of this method, continuous adaptation and attention to students' individual needs are required.

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