The Influence of Using Travel Miniature Media through the Problem-Based Learning (PBL) Model and Teaching at the Right Level (TaRL) Approach on Mathematics Learning Outcomes of Grade 5 Elementary School Students

Sandi Budiana[1], Dwi Rahayu[2], Ni'matul Jannah[3], Arief Rahman Efendy[4]
[1,2,3,4]Indonesia Teacher Professional Education Program, Universitas Pakuan, Kota Bogor, Indonesia
[2,3,4]SDN Layungsari 2, Kota Bogor, Indonesia

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ABSTRACT

Few studies have combined Problem-Based Learning (PBL) and Teaching at the Right Level (TaRL) to enhance elementary students' understanding of geometric concepts. Conventional teacher-centered instruction often limits students' active engagement, particularly in abstract mathematics topics such as the perimeter of plane figures. This study aimed to investigate the impact of integrating miniature journey media with Problem-Based Learning (PBL) and Teaching at The Right Level (TaRL) on mathematics learning outcomes. A pre-experimental one-group pre-test/post-test design was used, involving 22 fifth-grade students at SDN Layungsari 2 in Indonesia. Students completed a pre-test, received instruction using the intervention, and then completed a post-test. The assessment instrument included two descriptive items adjusted to students' ability levels. The data were analyzed using descriptive statistics and a paired samples t-test. Normality was confirmed via the Shapiro–Wilk test. The results indicated a statistically significant improvement in scores from the pre-test ($M = 41.64$, $SD = 12.4$) to the post-test ($M = 64.59$, $SD = 14.2$), $t(21) = 3.94$, $p = .001$, with a moderate effect size ($d = 0.70$). These findings suggest that combining miniature journey media with PBL and TaRL can support students' learning of perimeter concepts. Further research with control groups and larger samples is recommended to validate and extend these findings.

Corresponding Author:

Sandi Budiana
Faculty of Teacher Training and Education, Teacher Professional Education, Pakuan University
Email: budianasandi@gmail.com

1. INTRODUCTION

Education is widely regarded as being of pivotal significance in life. The right to a decent education is an inherent human right. This fundamental principle underscores the role of education in shaping individuals and societies. This assertion is further reinforced in the opening of the 1945 Constitution, paragraph four, which states that education is the right of every nation [1]. Education has been shown to facilitate the optimal development of human potential, thereby exerting a positive influence on individuals and their respective environments. Thus, providing access to quality education is not only a legal obligation but also a cornerstone for national development.

Mathematics is widely acknowledged as being of pivotal importance within the education system, particularly at the elementary level. Research has demonstrated the critical role of mathematics in fostering students' logical and analytical thinking skills. Mathematics is a subject taught at the elementary school level, and its knowledge is closely related to everyday life [2]. This lesson is not solely concerned with calculating numbers; it is also conducive to cultivating logical, systematic, and critical thinking skills when confronted with real-life problems. Mathematics can be defined as a system of numerical calculations and formulas. Consequently, it is not surprising that mathematics is often perceived as challenging and abstract by students, particularly when it comes to topics such as the perimeter of flat shapes [3]. This perception of difficulty can hinder students' engagement and achievement, necessitating instructional strategies that bridge the gap between abstract content and concrete understanding.

To address this issue, innovations in learner-centered pedagogical practices have become increasingly important. Problem-based learning (PBL) is a pedagogical approach that emphasizes authentic, real-life problem engagement and has been proven to improve mathematics performance and critical thinking at the elementary level. For instance, Kurniasih [4] discovered that PBL considerably augmented learning outcomes and critical thinking among Grade 5 students in Central Java. Arifin [5] demonstrated that PBL enhanced creative thinking in 4th-grade mathematics, with experimental group scores reaching 84.7 compared to 71.0 in the control group. In a similar vein, Tanjung [6] reported that PBL significantly enhanced learning outcomes and critical thinking for Grade 5 students in Medan. Concurrently, the Teaching at the Right Level (TaRL) approach groups students based on ability rather than age, focusing on foundational numeracy until mastery is achieved [7]. The efficacy of TaRL in enhancing fundamental arithmetic competencies has been well-documented [8]; however, its potential in geometry, particularly in the domain of perimeter, remains under-explored. Given the abstract nature of perimeter concepts, exploring how TaRL could support their acquisition is a timely and necessary inquiry.

Recent classroom-level studies suggest that combining PBL and TaRL may synergistically enhance numeracy and representation skills [9], but none specifically target perimeter concepts. This constitutes a clear research gap: while both PBL and TaRL are effective individually, their integrated application to abstract geometry has not been studied. The lack of empirical evidence on this integration underscores the need for innovative interventions that support students' geometric thinking, particularly among underserved or low-performing groups.

In order to facilitate a more intuitive comprehension of the abstract concept of perimeter, the utilization of miniature-journey media is hereby proposed. It is posited that students can travel around shapes, thereby facilitating the conceptualization of perimeters and their subsequent measurement in a contextual context. This media invites kinesthetic interaction, enabling learners to embody mathematical ideas through movement and observation. This approach is consistent with Bruner's learning sequence, which progresses from concrete to pictorial to abstract, and with Van Hiele's geometric reasoning model, which emphasizes the importance of tangible experiences in preparing for abstract reasoning. By aligning pedagogical strategies with established cognitive theories, this study aims to enhance both conceptual understanding and engagement.

This study aims to examine the effect of integrating miniature-journey media with the PBL model and TaRL approach on the perimeter learning outcomes of fifth-grade elementary school students. Specifically, the study seeks to determine whether this integrated approach can enhance students' understanding, motivation, and achievement in learning geometry, particularly in mastering the concept of perimeter.

2. METHOD

This research employed a quantitative approach with a pre-experimental design, specifically the one-group pretest-posttest design. This design involves a single group of participants who are tested before and after the intervention. While this approach provides insight into potential changes resulting from the intervention, it does not include a control group, which limits the ability to rule out the influence of external variables, such as maturation, testing effects, or environmental factors. The design was chosen due to practical constraints in the school setting, including limited class availability and ethical considerations regarding the withholding of intervention from students.

Table 1. One Group Pretest-Posttest Design Research Pattern

Pre-test	Treatment	Post-test
O_1	X	O_2

Description:

O_1 = pre-test (initial test before treatment)

X = treatment in the form of learning using miniature travel media through the TaRL approach and PBL model

O_2 = post-test (final test after learning using miniature travel media)

The research includes an independent variable, which influences change, and a dependent variable, which is affected by the independent variable. The independent variable in this study is the use of miniature travel media in the Teaching at the Right Level (TaRL) learning approach, which utilizes the Problem-Based Learning (PBL) model. In contrast, student learning performance on flat geometry material is the dependent variable.

The TaRL learning approach in this study was employed to ensure that each student learns at their respective ability level. Before the learning process, students were grouped based on the results of the initial test (pre-test). In implementing learning using miniature travel media, researchers provide guidance tailored to the level of students' understanding of the concept of flat shapes, ensuring that learning interventions are relevant to each student's needs.

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Participants

The participants consisted of 22 fifth-grade students (10 male and 12 female) from class VB at SDN Layungsari 2, Bogor, Indonesia. Their ages ranged from 10 to 11 years. Most students came from lower to middle socioeconomic backgrounds. The class was selected purposively as part of Phase C in the Indonesian Kurikulum Merdeka. All students participated in the intervention as part of their regular learning activities.

Research Instruments

The assessment instrument consisted of two open-ended essay questions designed to evaluate students' understanding of the perimeter of plane figures. The questions were tailored to match students' ability levels based on the TaRL grouping. The instrument was reviewed by two qualified educators holding master's degrees in education, who assessed each item for clarity, relevance, and curricular alignment. Based on their feedback, revisions were made to improve the quality of the items. Although no Content Validity Index (CVI) was calculated, the experts' consensus ensured that the items were suitable for the intended learning objectives.

To ensure scoring reliability, two independent raters assessed students' responses using a standardized rubric. Because only the final scores per student were available, inter-rater agreement was calculated using Cohen's Kappa based on the combined scores from both items. The results of the analysis showed a Kappa value of 0.713, indicating a high level of agreement (substantial agreement) between assessors, as classified [10].

Research Procedures

The procedure was divided into three main stages. The first stage involved administering a pre-test to assess students' initial understanding of the perimeter of plane figures. The results of this test were also used to group students based on ability levels as part of the TaRL implementation.

In the second stage, students participated in a learning session that integrated miniature journey media with the Problem-Based Learning (PBL) model. During this stage, students engaged in contextual problem-solving activities, group discussions, and simulated navigation tasks that helped them explore perimeter concepts through a combination of visual and experiential learning. The instruction was differentiated according to students' ability groups.

The final stage involved administering the post-test, which aimed to evaluate students' learning progress after the intervention. The same assessment instrument was used to facilitate a meaningful comparison with the pre-test results.

Data Analysis Techniques

Pre-test and post-test data analysis include descriptive statistics (mean, minimum, maximum, and standard deviation) as well as inferential statistics through paired t-tests. A normality test is conducted first as a requirement for using a parametric test.

Ethical Considerations

This study received ethical clearance from the Research Ethics Committee of Pakuan University. Formal permission was obtained from the school principal. Although written consent was not collected from parents or guardians, the learning activities were integrated into the regular school curriculum, posed minimal risk, and were conducted with transparency and cooperation from the school community. All student data were anonymized for research purposes.

Normality Test

A data normality test is conducted to determine whether the data obtained are normally distributed or not. The dependent variables in this study are the pre-test and post-test learning outcomes, which are then tested for normality using SPSS version 20.0. The results of the normality test refer to the following criteria [11]:

1. Significance values above 0.05 indicate that the data follows a normal distribution
2. Values below 0.05 indicate that the data is not normally distributed

N-Gain Test

To determine the effectiveness of learning in improving student learning outcomes, researchers conducted an N-Gain test. The following criteria are used as references in interpreting the results of the analysis [12].

Table 2. N-Gain Classification

N-gain Value	Criteria
$g \geq 0,7$	High
$0,3 \leq g < 0,7$	Middle
$g < 0,3$	Low

Hypothesis

The next stage involves researchers conducting hypothesis testing. Parametric statistics are applied as an analysis technique if the data meet the assumption of normal distribution, and non-parametric techniques are used if the data is not normally distributed [13]. To determine the effect of the variables, a t-test (paired sample t-test) was used with the help of SPSS version 20.0. The hypotheses in this study are,

Ha : There is an effect of using miniature travel media with the PBL model and the TaRL approach on mathematics learning outcomes.

Ho : There is no significant effect on mathematics learning outcomes when using miniature travel media in conjunction with the PBL model and the TaRL approach.

The decisions used are as follows:

1. A significance level above 0.05 indicates that there is insufficient evidence to reject H_0
2. A significance level below 0.05 indicates that H_0 is rejected and Ha is accepted

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3. RESULTS AND DISCUSSION

3.1. Results

This study employed a pre-experimental one-group pretest-posttest design involving 22 fifth-grade students at SDN Layungsari 2, Bogor City. The independent variables were the use of miniature travel media, the implementation of the Problem-Based Learning (PBL) model, and its integration with the Teaching at the Right Level (TaRL) approach. The dependent variable was students' mathematics learning outcomes on the topic of perimeter of plane figures. Descriptive statistics for both the pre-test and post-test scores are presented in the following table: pre-test and post-test values.

Table 3. Pre-test and Post-test Values

Variable	N Maks	N Min	Mean	SD	95% Confidence Interval F	
					Lower Bound	Upper Bound
Pre-test	64	20	41.46	14.325	35.29	47.99
Post-test	100	29	64.59	23.392	54.22	74.96

Source: Research, 2025

The average post-test score was higher than the pre-test score, with no overlap in their 95% confidence intervals. To determine whether the change in scores was statistically significant, a paired-sample t-test was conducted. The results revealed a statistically significant increase in scores from the pre-test (M = 41.64, SD = 14.33) to the post-test (M = 64.59, SD = 23.39), t(21) = -3.941, p = .001, with a large effect size (Cohen's d = 0.713).

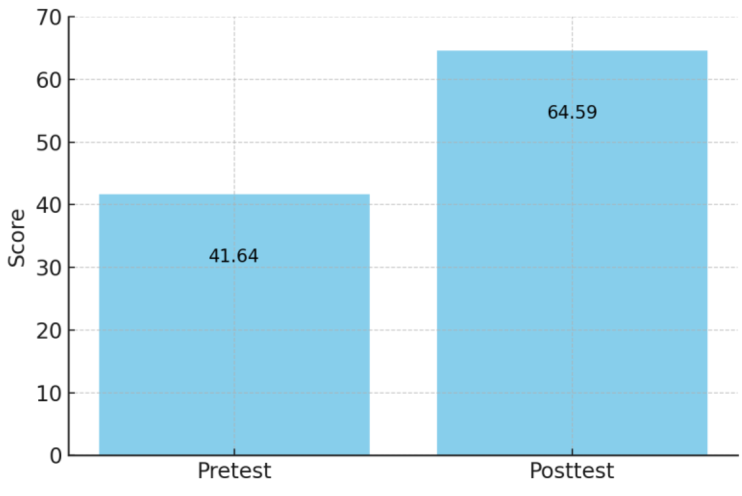

Figure 1. Bar chart comparing the average pre-test and post-test scores
Source: Research, 2025

Subsequently, the researcher conducted an N-Gain analysis using SPSS version 20.0 to assess learning improvement based on individual score differences. The results of the analysis are presented in the following table:

Table 4. N-Gain Score

N-Gain	N	Min	Max	Mean	Category
Score	22	-0.61	1.00	0.3499	Moderate improvement

Source: SPSS version 20.0, 2025

Based on Hake's classification, the average N-Gain score of 0.3499 indicates a moderate level of improvement.

To test the hypothesis, a paired samples t-test was conducted to determine whether there was a significant effect of using miniature travel media combined with the PBL model and integrated with the TaRL approach on students' mathematics achievement in the topic of perimeter of plane figures.

Table 5. Paired Simples T-Test

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pair 1 Pretest-Posttest	-22.955	27.321	5.825	-35.068	-10.841	-3.941	21	.001

Source: SPSS version 20.0, 2025

The analysis showed a statistically significant increase in scores, $t(21) = -3.941$, $p = .001$, with a mean difference of -22.955 ($SD = 27.321$), and a 95% confidence interval from -35.068 to -10.841. The results indicate a strong impact of the intervention.

3.2. Discussion

Students often perceive mathematics as a difficult and uninteresting subject due to the abundance of formulas and abstract concepts [14]. This perception often leads to math anxiety and low motivation, both of which negatively impact student performance. Mathematics learning is closely related to daily activities and can be made more engaging when presented in a contextual manner, such as in the topic of perimeter of plane figures [15]. Teacher-centered learning often limits active student participation, resulting in passive learners who struggle to explore their understanding of the material thoroughly. Therefore, a shift toward more engaging and student-centered pedagogies is essential to foster deeper conceptual understanding and sustained interest in mathematics.

To foster active learning, teachers should implement effective strategies, including the use of interactive learning media and appropriate instructional models. One proven method to enhance mathematics learning outcomes is the Problem-Based Learning (PBL) model. Several studies have shown that applying the PBL model significantly improves students' performance in mathematics, especially in topics such as fractions [16], [17]. This model encourages student autonomy, critical thinking, and collaborative problem-solving, all of which are essential for mathematical literacy in the 21st century. The use of media that stimulates real-life applications can further enrich the PBL experience, enabling students to connect abstract concepts to their everyday surroundings.

In this study, the miniature journey media was used alongside the PBL model, integrated with the Teaching at the Right Level (TaRL) approach. PBL creates a learning environment where students are the main agents in solving meaningful and real-world problems [18]. Students explore the concept of perimeter through interactive activities using a miniature map of their school, making abstract concepts more concrete and easier to grasp [19]. This approach not only enhances cognitive engagement but also promotes spatial

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reasoning and contextual understanding, key components in the development of geometric thinking among young learners.

The TaRL approach complements this process by grouping students according to their actual ability levels rather than their formal grade levels [20]. This ensures that each student receives instruction tailored to their learning needs. This differentiation enables struggling students to master foundational concepts while allowing more advanced students to engage with more complex problems, thereby maximizing engagement and learning efficiency [21]. This finding aligns with previous studies emphasizing the benefits of adaptive instruction based on students' readiness [1], [11], [13], [22]. Moreover, this layered instruction aligns with the principles of equity in education by ensuring that every student, regardless of their initial proficiency level, has the opportunity to make meaningful progress.

The results of this study support the effectiveness of the integrated PBL and TaRL approach. The average student score increased from 41.64 (pre-test) to 64.59 (post-test), and the paired sample t-test showed a statistically significant difference, $t(21) = -3.941$, $p = .001$. The effect size was large (Cohen's $d = 0.713$), indicating a strong influence of the intervention. Additionally, the N-Gain value of 0.3499 indicates a moderate improvement in student learning outcomes. These results are consistent with prior studies that emphasize the importance of contextual, active, and differentiated learning strategies in mathematics instruction [15], [23]. This empirical evidence reinforces the pedagogical value of combining instructional innovation with tailored support, particularly in foundational topics such as geometry.

However, alternative explanations should also be considered. For example, the increase in post-test scores might partly result from test familiarity, as students were exposed to similar types of questions in both the pre-test and post-test. Additionally, natural cognitive development over the duration of the study (maturation effect) may have influenced the outcomes [24]. Moreover, the possibility of a Hawthorne effect—where students perform better simply because they are aware of being part of an intervention—should not be overlooked. Recognizing these potential biases is crucial for interpreting the results with appropriate caution.

This study also offers practical implications for elementary school teachers. The miniature journey media used in this intervention is accessible, engaging, and adaptable [25]. Teachers can replicate this media to teach other mathematics topics such as area or measurement. When combined with structured approaches like PBL and TaRL, these strategies can help accommodate diverse learning needs and enhance student participation in the classroom. Such practical tools are particularly valuable in resource-limited settings, where affordable yet effective media can transform the quality of instruction and student outcomes.

Despite the promising findings, this study has several limitations. First, the sample size was relatively small and limited to a single school, which limits the generalizability of the findings. Second, the study did not involve a control group, making it difficult to attribute the results solely to the intervention. Third, the duration of the intervention was short, which limits the ability to assess long-term learning retention. These limitations suggest that while the initial results are encouraging, broader validation is necessary before advocating for large-scale implementation.

Future studies should consider using a quasi-experimental design with control groups to strengthen causal inferences. It is also recommended to investigate the long-term effects of the integrated approach and its applicability to different mathematics topics or student age groups. Additionally, incorporating qualitative data such as student reflections and classroom observations could provide deeper insights into how and why the intervention works, thereby enriching future instructional designs.

4. CONCLUSION

The integration of miniature journey media with the Problem-Based Learning (PBL) model and the Teaching at the Right Level (TaRL) approach proved to be an effective instructional strategy for improving fifth-grade students' understanding of the perimeter of plane figures. This improvement was evident from the statistically significant increase in learning outcomes between the pre-test and post-test scores, indicating that combining contextual media with student-centered learning models can meaningfully enhance conceptual comprehension in geometry.

However, these findings should be interpreted with caution, as they remain preliminary due to the study's limited scope and sample size. The use of a pre-experimental design, a relatively small sample size, the absence of a control group, and a short implementation period limit the generalizability of the results. These constraints highlight the need for further empirical exploration to validate and expand upon the observed outcomes.

In light of these results, teachers are encouraged to explore the use of context-based, interactive media and learner-centered pedagogies, particularly PBL and TaRL, as promising approaches to teaching abstract mathematical topics, such as perimeter. Such strategies may foster deeper engagement and understanding, especially when tailored to students' readiness and learning needs.

Nevertheless, future research is strongly recommended to employ more rigorous experimental designs, larger and more diverse participant samples, and extended intervention durations. This would enable a more comprehensive evaluation of the long-term effectiveness and broader applicability of the integrated approach in various educational settings and across different mathematical domains.

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