

The Effect of Lumi Education-Based PBL on Students' Mathematical Problem-Solving and Mathematical Disposition

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Abstract

This study aimed to examine the simultaneous and partial effects of Lumi Education-Based PBL on students' mathematical problem-solving ability and mathematical disposition. A quasi-experimental design with a posttest-only control group was employed, involving 69 Grade XI students at SMAN 1 Pekalongan, selected through cluster random sampling. The experimental group received Lumi Education-Based PBL, while the control group received expository learning. Data were analyzed using Hotelling's T^2 for the multivariate test and independent-samples t-tests for univariate analysis, supplemented by Cohen's d effect size calculations. The multivariate analysis revealed a significant simultaneous effect of Lumi Education-Based PBL on both outcome variables ($p = 0.034 < 0.05$). Univariate analysis further showed that the experimental group significantly outperformed the control group in mathematical problem-solving ability ($d = 0.605$), whereas no significant difference was found in mathematical disposition between the two groups. These findings suggest that Lumi Education-Based PBL effectively enhances students' mathematical problem-solving ability, while its effect on mathematical disposition remains inconclusive and warrants further investigation, particularly with longer intervention periods.

INTRODUCTION

As a developing country, Indonesia faces various challenges in improving the quality of its human resources. High-quality human resources reflect a generation's readiness to carry forward the continuity of governance from one generation to the next (Suryawan et al., 2023). Therefore, education becomes a critically important aspect in shaping superior and competitive human resources, as well as serving as the primary key to a nation's progress (Earthadara & Kismiantini, 2025). Through education, individuals are not only equipped with knowledge, but their potential and skills are also developed to meet the demands of an increasingly complex era.

As times progress, the world of education has undergone a paradigm shift, moving away

from a focus on memorizing information toward developing critical thinking, creativity, and problem-solving abilities (Suryawan et al., 2023). This shift has also impacted mathematics learning, which no longer emphasizes only the understanding of concepts and theorems, but also trains students to apply logical reasoning in solving problems. This condition demands that teachers be able to facilitate the learning process effectively, as affirmed by Kamal & Istiyono (2023), who stated that teachers play an important role in helping students understand mathematical concepts.

Ideal mathematics learning should fundamentally develop mathematical proficiency in a comprehensive manner. As proposed by Kilpatrick et al. (2001), mathematical proficiency encompasses five key aspects, namely conceptual understanding, adaptive reasoning, procedural fluency, strategic competence, and productive mathematical disposition. Mastery of these five aspects is expected to equip students to be not only academically excellent, but also to possess positive attitudes and confidence in solving mathematical problems.

However, the reality of mathematics learning in Indonesia still reflects conditions far from ideal. PISA 2022 data recorded that the average mathematics score of Indonesian students was only 366, well below the OECD member country average of 472 (Earthadara & Kismiantini, 2025). TIMSS findings also revealed that Indonesian students experience significant difficulties in the cognitive reasoning and problem-solving domains, although they perform relatively better in recalling basic facts (Khairani, 2023). This condition indicates that most Indonesian students are only able to solve routine problems that follow previously taught procedures, while their ability to solve non-routine problems requiring higher-order reasoning remains limited. Mathematical problem-solving ability is one of the most crucial competencies for students, both for supporting academic achievement and as a life skill needed to navigate the dynamics of the modern era (Suryawan et al., 2023). However, empirical findings indicate that Indonesian students' mastery of non-routine problem-solving remains inadequate (Amalina & Tibor Vidakovich, 2023; Anggreini et al., 2022).

The low level of mathematical problem-solving ability cannot be separated from the affective dimension of learning, particularly mathematical disposition. The tendency to view mathematics as a rational, useful, and worthwhile field, accompanied by confidence and perseverance in facing mathematical tasks, constitutes the core essence of mathematical disposition (Kilpatrick et al., 2001). In relation to academic achievement, the level of mathematical disposition is directly proportional to students' ability. Students with a high disposition are able to apply all problem-solving steps, while those with a low disposition are only able to understand the problem itself (Azizah & Fadlikah, 2023). The state of mathematical disposition among Indonesian students is currently still considered concerning. Even at the university level, the majority of mathematics education students (68.09%) are reported to possess mathematical disposition only at a moderate level (Machmud et al., 2022). This condition is further exacerbated by a trend of drastic decline in mathematical disposition throughout the educational levels, where the positive enthusiasm of younger students reaching 76% reverses dramatically to 81% negative enjoyment among older students (Deal et al., 2025). A similar condition was also identified at SMAN 1 Pekalongan. Interviews with the Grade XI mathematics teacher revealed that students tend to be passive, rarely ask questions, and show a high degree of dependence on the teacher in determining problem-solving strategies. Furthermore, students also quickly lose motivation when faced with challenging problems that are dissimilar to the examples taught, indicating low levels of self-confidence, cognitive flexibility, and mathematical problem-solving ability.

One of the root causes of the low levels of both aspects lies in learning practices that still tend to be teacher-centered (Gozali et al., 2022). In expository-based learning, the teacher explains the material and problem-solving steps and students then work on similar exercises. Although this approach is effective in developing procedural fluency, it has limitations in

fostering higher-order thinking skills (Woods & Copur-gencturk, 2024). This approach is also less conducive to developing a positive mathematical disposition, as students do not have the opportunity to experience the process of discovery, face meaningful challenges, or understand the relevance of mathematics in real life (Haryanti & Wijaya, 2023).

As an alternative solution, the PBL model is considered to have great potential in simultaneously accommodating the development of both the cognitive and affective aspects of students (Gozali et al., 2022). This student-centered learning model initiates its process through the presentation of authentic and relevant problems, thereby encouraging students to actively engage in inquiry and investigation. The effectiveness of this model has been demonstrated by various studies, one of which is Gozali et al. (2022), which showed that the implementation of PBL led to significant improvements in both problem-solving ability and students' mathematical disposition compared to conventional learning. In line with this, Yuhana & Fajari (2025), in a meta-analysis of 38 articles, also confirmed that PBL has a strong and consistent impact on improving problem-solving skills across various disciplines. Furthermore, Alashwal & Barham (2025) found that the positive effects of PBL are not only immediate but also sustained over the long term.

Nevertheless, the implementation of PBL faces several practical challenges, including the need for longer time allocation, students' still-passive learning culture, and difficulties in managing large classes (Gozali et al., 2022; Khafifah & Rahayu, 2025). To address these limitations, the integration of interactive learning media based on digital technology represents a relevant and promising solution. A study by Meng et al. (2023) found that e-learning platforms can help teachers manage PBL more efficiently through the provision of materials, tracking of learning progress, and automatic feedback delivery. This is also supported by the research of Agustinsa et al. (2023), which demonstrated that the implementation of PBL assisted by contextual student worksheets (LKPD) had a positive impact on improving students' mathematical problem-solving ability.

One innovative platform that can be integrated into PBL is Lumi Education, which is based on H5P. Lumi Education is an open-source desktop application that enables educators to create interactive learning content without requiring a continuous internet connection (Ogris, 2022). The platform provides various types of interactive content, such as Interactive Video, Course Presentation, Quiz, and Branching Scenario, which can be tailored to learning needs (Lestari et al., 2025). Several studies have demonstrated its positive impact across various contexts, including Salsabila et al. (2025), who reported a significant improvement in students' scientific argumentation skills, and Rizka et al. (2025), who confirmed its positive contribution to students' critical thinking ability.

Although Lumi Education has shown positive effects in other subject areas, its application in mathematics learning, particularly with respect to problem-solving ability and mathematical disposition, remains largely unexplored. Moreover, prior studies examining these two variables together generally rely on simple univariate analyses such as t-tests or ANOVA (Gozali et al., 2022; Kusuma et al., 2024), rather than multivariate approaches (MANOVA) capable of capturing their simultaneous effect. Based on this gap, this study aims to examine the effect of Lumi Education-Based PBL on the mathematical disposition and mathematical problem-solving ability of Grade XI students at SMAN 1 Pekalongan simultaneously. This study offers novelty by being among the first to examine the simultaneous effect of Lumi Education-Based PBL on both variables using a multivariate (MANOVA) approach, an analysis rarely applied in prior PBL research despite the conceptual interconnection between cognitive and affective outcomes. Theoretically, this study contributes to the growing body of literature on PBL integrated with interactive digital media by demonstrating how such media can be evaluated through a multivariate lens. Practically, it offers teachers an alternative instructional approach and media, namely Lumi Education-

Based PBL, that can be implemented to enhance both the cognitive and affective outcomes of mathematics learning.

METHOD

This study employed a quantitative approach with a quasi-experimental research design using a posttest-only control group design. This design was selected because the study involved two class groups receiving different treatments, namely the experimental class, which received instruction using Lumi Education-Based PBL, and the control class, which received instruction using the expository approach as commonly implemented by the teacher. The research design is presented in [Table 1](#).

Tabel 1. Research Design

Class	Treatment	Posttest
Experimental (E)	X	O
Control (C)	-	O

Note:

X = treatment using Lumi Education-Based PBL

O = the same posttest administered to both classes

This study was conducted at SMA Negeri 1 Pekalongan during the even semester of the 2025/2026 academic year, specifically from February 3 to May 7, 2026. The study population consisted of all Grade XI students at SMA Negeri 1 Pekalongan, who were distributed across nine classes. Sampling was carried out using cluster random sampling, a technique that divides the population into several groups or clusters based on certain criteria, after which a number of clusters are randomly selected as the sample ([Supriadi et al., 2022](#)). Based on this technique, class XI Kartini 5 was selected as the experimental class, consisting of 34 students, and class XI Kartini 4 as the control class, consisting of 35 students. All classes had a relatively similar level of homogeneity, as there were no accelerated or advanced classes, meaning that high-ability students were evenly distributed across each class.

This study involved two variables. The independent variable, namely the implementation of Lumi Education-Based PBL, and the dependent variables, consisting of students' mathematical problem-solving ability and mathematical disposition. Data were collected through two techniques: a test technique and a non-test technique in the form of a questionnaire. The test instrument consisted of five essay items on the topic of logarithmic functions, used to measure students' mathematical problem-solving ability. The non-test instrument was a mathematical disposition questionnaire comprising 20 statement items using a four-category Likert scale, developed based on the mathematical disposition indicators proposed by NCTM ([Hudiria et al., 2022](#)), covering the aspects of self-confidence, curiosity, perseverance, flexibility, and reflectiveness. Prior to use in the study, both instruments were piloted with 33 students from class XII Kartini 5. The quality assessment of the test instrument included a validity test using Aiken's V index, a reliability test using Cronbach's Alpha, an item difficulty level test, and a discriminating power test, yielding a holistic validity coefficient of 0.93 and a reliability coefficient of 0.76. The quality assessment of the non-test instrument included a validity test using Aiken's V index and a reliability test using Cronbach's Alpha, yielding a holistic validity coefficient of 0.98 and a reliability coefficient of 0.84. Based on these results, both the test and non-test instruments were declared valid and reliable for use in the study.

The data analysis technique employed in this study was inferential statistics. Prior to the treatment, a preliminary data analysis was conducted using the End-of-Semester Summative

Assessment (ASAS) scores to ensure the equivalence of the initial ability of both classes, through a Shapiro-Wilk univariate normality test, a variance homogeneity test using the F-test, and a mean equivalence test using an independent samples t-test (Walpole et al., 2012). The results of the preliminary data analysis indicated that both classes were normally distributed (p-value: experimental class = 0.062; control class = 0.371), had homogeneous variances (p-value = 0.342), and showed no significant difference in means (p-value = 0.699), thereby confirming that both classes were equivalent prior to the treatment. The ASAS scores were used specifically to verify that students in both classes had comparable general mathematical ability before treatment, as this study employed a posttest-only control group design in which the outcome variables were measured solely after treatment. This approach ensured that the resulting posttest differences could be attributed to the treatment itself rather than to pre-existing disparities in students' general mathematical ability between the two groups.

The main hypothesis testing was conducted using Hotelling's T^2 test as a form of multivariate analysis (MANOVA) to examine the difference in the means of two dependent variables simultaneously between the two groups (Nascimento et al., 2025). The assumptions verified prior to this test included multivariate normality using the Henze-Zirkler test (Annisafiya et al., 2023) and homogeneity of the variance-covariance matrix using Box's M test (Retnawati et al., 2024). The Hotelling's T^2 test statistic used is as follows:

$$T^2 = (\bar{x}_1 - \bar{x}_2 - \mu_0)' \left[\left(\frac{1}{n_1} + \frac{1}{n_2} \right) S_p \right]^{-1} (\bar{x}_1 - \bar{x}_2 - \mu_0) \quad (1)$$

All calculations were performed using R software at a significance level of $\alpha = 0.05$. If the MANOVA test indicated a significant simultaneous difference, a follow-up test (post hoc) was conducted using an independent samples t-test on each dependent variable separately, in order to identify which variable contributed to the observed difference (Walpole et al., 2012).

RESULTS AND DISCUSSION

Results

Research data were obtained through a mathematical problem-solving ability test instrument and a mathematical disposition questionnaire administered after the learning process was completed. The experimental class received treatment using Lumi Education-Based PBL, while the control class used the expository approach. A recapitulation of the descriptive statistics of the posttest results for both variables in each class is presented in Table 2.

The final data obtained through the test instrument and questionnaire were analyzed using inferential statistics with the assistance of R software. Prior to further analysis, normality assumption testing was conducted to ensure that the data in each group followed a normal distribution, both univariately and multivariately. The results of these tests served as the basis for determining the appropriate statistical analysis technique in the subsequent stage. The test results are presented in Table 3.

As shown in Table 3, the multivariate normality test using the Henze-Zirkler test yielded an HZ statistic of 0.3200 and a p-value of 0.7890 for students who received treatment Lumi Education-Based PBL. For the group of students who received treatment using the expository approach, the HZ statistic was 0.3066 with a corresponding p-value of 0.8249. Since both groups had p-values > 0.05 , H_0 was not rejected, indicating that the posttest data from both groups satisfied the multivariate normality assumption.

Table 2. Descriptive Statistics of the Posttest on Mathematical Problem-Solving Ability and Mathematical Disposition

Statistical Data	Mathematical Problem-Solving Ability		Mathematical Disposition	
	Experimental Class	Control Class	Experimental Class	Control Class
N	34	35	34	35
Mean	61.54	51.86	56.96	57.42
Median	61.25	50	56.26	56.51
Standard Deviation	17.58	14.28	7.11	8.55
Variance	309.10	203.80	50.58	73.03
Minimum Score	25	25	36.53	32.80
Maximum Score	90	80	71.54	77.05
Range	65	55	35.01	44.25

Table 3. Univariate and Multivariate Normality Tests

Group	Variabel	Henze-Zirkler		Shapiro-Wilk	
		statistic	p-value	statistic	p-value
PBL	Mathematical Problem-Solving Ability	0.3200	0.7890	0.9691	0.4358
	Mathematical Disposition			0.9756	0.6294
Expository	Mathematical Problem-Solving Ability	0.3066	0.8249	0.9804	0.7709
	Mathematical Disposition			0.9600	0.2283

The results of the univariate normality test using the Shapiro-Wilk test indicated that all observed variables in both groups satisfied the univariate normality assumption. For the PBL group, the mathematical problem-solving ability variable yielded a test statistic of 0.9691 with a p-value of 0.4358, while the mathematical disposition variable had a statistic of 0.9756 and a p-value of 0.6294. Since both p-values exceeded 0.05, H_0 was accepted, confirming that the posttest data for these variables in the PBL group were normally distributed. A similar finding was observed in the expository group. The mathematical problem-solving ability variable produced a Shapiro-Wilk statistic of 0.9804 with a p-value of 0.7709, while the mathematical disposition variable yielded a statistic of 0.9600 and a p-value of 0.2283. Since all p-values exceeded the threshold of 0.05, H_0 was accepted, indicating that the posttest data for these variables in the expository group satisfied the univariate normality assumption.

Overall, the results of both the multivariate and univariate normality tests confirmed that the data met the normality requirements. Therefore, further analysis could proceed by examining the homogeneity assumption. Homogeneity testing was conducted to assess the equality of the variance-covariance matrices across groups, which is an important prerequisite for MANOVA. Specifically, multivariate homogeneity was evaluated using Box's M test, while univariate homogeneity was assessed using the F-test, both conducted using R software, with the results presented in [Table 4](#).

Table 4. Homogeneity Tests

Test Type	Variable	Statistic	df	p-value
Box's M (Multivariate)	Mathematical Problem-Solving Ability & Mathematical Disposition	$\chi^2 = 2.876$	$df = 3$	0.411
F-test (Univariate)	Mathematical Problem-Solving Ability	$F = 1.517$	$df_1 = 33$ $df_2 = 34$	0.232
F-test (Univariate)	Mathematical Disposition	$F = 0.693$	$df_1 = 33$ $df_2 = 34$	0.294

Based on Table 4, the Box's M test yielded $\chi^2 = 2.876$ with a p-value of $0.411 > 0.05$, so H_0 was accepted. Accordingly, the variance-covariance matrices of both groups were homogeneous, meaning that there was no difference in population variances. A similar finding was observed in the univariate homogeneity test: for the mathematical problem-solving ability variable, a p-value of 0.232 was obtained, while for the mathematical disposition variable, a p-value of 0.294 was obtained. Both variables had p-values > 0.05 , so H_0 was accepted, indicating that there was no difference in population variances and that the data originated from a homogeneous population.

The next stage involved mean difference analysis using the T-test to examine differences in population means. The mean difference analysis between the two groups in this study was intended to determine whether there was a significant difference between the implementation of Lumi Education-Based PBL and the expository approach with respect to students' mathematical problem-solving ability and mathematical disposition. This testing was conducted through two approaches: multivariately using Hotelling's T^2 test, and univariately using the independent samples t-test.

Table 5. Multivariate and Univariate Independent Two-Population Mean Tests

Type Test	Variable	Statistic	df	p-value
Hotelling's T^2	Mathematical Problem-Solving Ability & Mathematical Disposition	$T^2 = 6.777$ $T_{table} = 6,367$	$df_1 = 0.95$ $df_2 = 65.05$	0.034
t-test	Mathematical Problem-Solving Ability	$t = 2.516$	$df = 67$	0.007
t-test	Mathematical Disposition	$t = -0.243$	$df = 67$	0.596

Based on Table 5, the Hotelling's T^2 test yielded a p-value of $0.034 < \alpha = 0.05$. Accordingly, H_0 was rejected, meaning that there was a significant simultaneous difference between the mathematical problem-solving ability and mathematical disposition of students in the experimental class using Lumi Education-Based PBL and those in the control class using the expository approach. However, the results of the subsequent univariate tests provided a more specific picture for each variable. For the mathematical problem-solving ability variable, the t-test yielded a t-value of 2.516 with a p-value of $0.007 < 0.05$, so H_0 was rejected, indicating that the posttest data showed a significant difference between the two groups in terms of mathematical problem-solving ability. This means that Lumi Education-Based PBL influenced students' mathematical problem-solving ability compared to the expository approach. Meanwhile, for the mathematical disposition variable, a t-value of -0.243 with a p-value of $0.596 > 0.05$ was obtained, so H_0 was accepted. This means there was no statistically significant difference in mathematical disposition between the two groups. In other words, based on this study, Lumi Education-Based PBL did not show a clear advantage over the expository

approach in improving students' mathematical disposition.

This finding may seem contradictory, but it can be explained simply. The multivariate test (Hotelling's T^2) evaluates both problem-solving ability and mathematical disposition together as a combined outcome, while the univariate t-tests evaluate each variable separately. Because the two variables are related to one another, a strong effect on one variable (problem-solving ability) combined with a small, consistent trend in the other (mathematical disposition) can be enough to produce a significant result when analyzed together, even though the disposition variable alone does not reach significance. In short, the multivariate test is more sensitive in detecting the overall treatment effect across both outcomes simultaneously, whereas the univariate test only captures the effect on each outcome individually.

Discussion

The multivariate analysis using Hotelling's T^2 test was conducted to determine whether there was a significant simultaneous difference between the experimental and control groups on both dependent variables, namely students' mathematical problem-solving ability and mathematical disposition. The test results showed a p-value of 0.034, which is less than the significance level of 0.05. This proves that Lumi Education-Based PBL had a significant simultaneous effect on both variables. Thus, the applied learning approach not only impacted students' cognitive aspects but was also closely related to students' affective aspects simultaneously.

This finding is consistent with previous research conducted by Gozali et al. (2022), who found that PBL-based learning had a significant effect on students' problem-solving ability and mathematical disposition. Similarly, Ndia et al. (2025) found that students with high mathematical disposition would achieve far more optimal results when taught using the PBL model. These findings reinforce the conclusion that students' cognitive and affective aspects are interconnected and not entirely separate in problem-based mathematics learning.

Theoretically, this result can be understood through Vygotsky's learning theory of the Zone of Proximal Development (ZPD), which refers to the optimal learning zone where the material is neither too easy nor too difficult for students (Schunk, 2012). In this regard, Lumi Education-Based PBL serves as an appropriate scaffolding tool. Real-world problems presented in the application prompt students to think independently at an optimal level. Meanwhile, group discussions and teacher guidance help students work through the more challenging parts. This combination produces a simultaneous impact on both problem-solving ability and mathematical disposition.

Although the multivariate test showed a significant simultaneous effect, the univariate results differed between the two variables: problem-solving ability showed a significant difference, while mathematical disposition did not. This pattern highlights the value of multivariate analysis in capturing treatment effects across related outcomes that may not each reach significance when tested separately.

At the univariate level, students in the experimental group achieved significantly higher problem-solving scores than those in the control group ($p = 0.007$), with a Cohen's d effect size of 0.605, which falls into the medium category (Cohen, 1988), indicating both a statistically and practically meaningful difference. This result is consistent with the meta-analysis by Yuhana & Fajari, (2025), who found that PBL has a strong and consistent impact on problem-solving skills across disciplines, as well as Fitriyah et al., (2022), who reported medium-to-large effect sizes for PBL implementation in mathematics.

The improvement in problem-solving ability appears closely tied to the specific role Lumi Education played within the PBL process. Each learning session opened with a contextual problem delivered through interactive videos and guided questions on the Lumi Education platform, designed to activate students' analytical thinking before they worked

through the standard problem-solving stages of understanding, planning, executing, and reviewing (Firda et al., 2023). This use of visual and interactive media aligns with Margareta & Karimah, (2025), who argue that instructional media should adapt to students' learning styles and help translate abstract concepts into more concrete forms, and is supported by Pratiwi et al., (2024), who found that interactive media in problem-based mathematics learning can meaningfully improve problem-solving ability by providing more concrete representations of problems. A similar pattern was reported by Agustinsa et al. (2023), whose students' scores improved substantially (from 33.78 to 69.00) when PBL was implemented with contextual teaching materials, reinforcing the idea that the concrete, interactive framing of problems, not the PBL model alone, played an important role in this study's results. By contrast, the teacher-centered control class offered fewer opportunities for students to independently construct problem-solving strategies Indriani et al., (2025). This finding is further supported by Alashwal & Barham, (2025), who demonstrated longitudinally that students who received PBL intervention over a longer period showed markedly better problem-solving ability compared to those taught using traditional methods.

At the univariate level, no statistically significant difference in mathematical disposition was found between the experimental and control groups ($p = 0.596$); the mean score in the experimental group was, in fact, slightly lower than in the control group. This result is unexpected, given that PBL is conceptually expected to also support the development of a positive mathematical disposition Kilpatrick et al. (2001).

Several possible explanations can be offered for this non-significant result, although these explanations are speculative and were not directly tested within this study. One possibility is that attitudes and dispositions toward mathematics develop through the accumulation of long-term learning experiences, making them difficult to shift within a short intervention (Bertolone-smith et al., 2026); this is broadly consistent with Machmud et al. (2022), who found that most Indonesian students remain at a moderate level of mathematical disposition regardless of instructional approach. Another possibility is that the mathematics teacher in the control class maintained a reasonable degree of student motivation and engagement despite using an expository approach, which may have narrowed the gap between groups. Sari & Arliani, (2023) note that mathematical disposition can develop through multiple learning pathways, not only through specific innovative models. A further possibility relates to students' adaptation to a new learning approach: because the disposition questionnaire was administered after only two PBL sessions, students who were newly exposed to more demanding, higher-order thinking tasks may have experienced some discomfort that temporarily suppressed their affective responses (Manuaba et al., 2022; Deal et al., 2025). It should be emphasized, however, that none of these explanations were directly measured in this study; they are offered as plausible interpretations consistent with prior literature, rather than as findings established by the present data.

It is worth noting that a significant multivariate effect was found even though the univariate test for disposition was not significant. This does not necessarily mean that Lumi Education-Based PBL had no relationship at all with students' mathematical disposition; rather, the non-significant univariate result may simply reflect the limited sensitivity of a single, short intervention period to detect change in an affective construct (Kamal et al., 2026). Research employing longer intervention periods, as recommended by Alashwal & Barham (2025), would be valuable for examining this affective dimension more thoroughly.

In summary, Lumi Education-Based PBL had a significant effect on students' mathematical problem-solving ability, while its effect on mathematical disposition was not statistically significant at the univariate level, despite the significant multivariate result for both variables combined. Teachers may consider implementing Lumi Education-Based PBL as a strategy to strengthen students' problem-solving ability, with attention to appropriate

scaffolding and problem contexts relevant to students' daily lives. Whether a longer implementation period would also yield measurable gains in mathematical disposition remains an open question for future research.

CONCLUSION

The results of this study indicate that Lumi Education-Based PBL had a simultaneous significant effect on students' mathematical problem-solving ability and mathematical disposition, although this effect was not equally strong for both variables when tested separately. Partially, Lumi Education-Based PBL was proven to have a significant effect on students' mathematical problem-solving ability ($t = 2.516$; $p = 0.007 < 0.05$) with an effect size of 0.605 (medium category), whereas its effect on mathematical disposition was not significant ($t = -0.243$; $p = 0.596 > 0.05$). Accordingly, Lumi Education-Based PBL can be considered an effective alternative strategy for improving students' mathematical problem-solving ability. Its effect on mathematical disposition, however, still requires further investigation. Therefore, the researcher recommends that future studies further examine the effect of Lumi Education-Based PBL on mathematical disposition, particularly by implementing interventions with a longer duration.

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