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THE EFFECTIVENESS OF PROBLEM BASED LEARNING MODEL AND LEARNING STYLE ON MATHEMATICAL CREATIVE THINKING ABILITY OF STUDENTS OF SMA NEGERI 1 SALAMAN MAGELANG

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ABSTRAK

Penelitian ini bertujuan untuk mengkaji efektivitas model PBL dan gaya belajar terhadap kemampuan berpikir kreatif matematis siswa. Penelitian ini merupakan penelitian eksperimen kuasi dengan desain eksperimen non-equivalent control group design. Populasi penelitian adalah siswa kelas XII SMA Negeri 1 Salaman Magelang tahun ajaran 2024/2025 yang mengambil mata pelajaran pilihan matematika tingkat lanjut yang berjumlah 143 siswa. Sampel penelitian berjumlah 71 siswa dengan teknik purposive sampling. Pengumpulan data dengan soal pretest-posttest kemampuan berpikir kreatif matematis. Instrumen penelitian berupa soal uraian yang mencakup kelancaran, keluwesan, keaslian serta kemampuan memperinci, memperkaya dan mengembangkan. Untuk analisis data yang digunakan adalah uji normalitas, uji homogenitas, dan uji hipotesis menggunakan anova dua arah. Temuan hasil penelitian sebagai berikut: (1) Terdapat perbedaan kemampuan berpikir kreatif matematis antara siswa yang telah mengikuti model PBL dan model pembelajaran langsung ditunjukkan dengan nilai Sig. 0.002 < 0.05. (2) Tidak terdapat perbedaan kemampuan berpikir kreatif matematis antara siswa dengan gaya belajar yang berbeda ditunjukkan dengan nilai Sig. 0.122 > 0.05. (3) Tidak ada pengaruh interaksi yang signifikan antara model pembelajaran dan gaya belajar siswa terhadap kemampuan berpikir kreatif matematis ditunjukkan dengan nilai Sig. 0.245 > 0.05.
Kata Kunci: *gaya belajar, kemampuan berpikir kreatif matematis, PBL*

ABSTRACT

This study aims to examine the effectiveness of the PBL model and learning styles on students' mathematical creative thinking abilities. This study is a quasi-experimental study with a non-equivalent control group design. The population of the study was 143 students of grade XII of SMA Negeri 1 Salaman Magelang in the 2024/2025 academic year who took advanced mathematics electives. The research sample was 71 students with a purposive sampling technique. Data collection with pretest-posttest questions on mathematical creative thinking abilities. The research instrument was in the form of descriptive questions covering fluency, flexibility, originality, and elaboration. For data analysis, the normality test, homogeneity test, and hypothesis test uses two way anova were used. The findings of the research results are as follows: (1) There is a difference in the ability to think creatively mathematically between students who have followed the PBL model and the direct learning model as shown by the Sig. 0.002 < 0.05. (2) There is no difference in the ability to think creatively mathematically between students with different learning styles as shown by the Sig. 0.122 > 0.05. (3) There is no significant interaction effect between the learning model and students' learning styles on the ability to think creatively mathematically as shown by the Sig. 0.245 > 0.05.
Keywords: *learning styles, mathematical creative thinking abilities, PBL*

INTRODUCTION

Creative thinking skills have emerged as an essential competency in the 21st century, crucial for navigating and succeeding amidst global challenges. This capability encompasses the ability to generate novel ideas, approach problems in innovative ways, and develop original solutions. An education system that effectively cultivates students' creative thinking skills is paramount to ensuring they can compete and adapt in a constantly evolving world. Within the discipline of mathematics, creative thinking is particularly vital; it not only enables individuals to solve complex problems but also to discover innovative solutions and apply mathematical concepts across diverse contexts. Therefore, it is imperative that mathematics education be intentionally designed to foster and strengthen this critical cognitive ability, moving beyond rote memorization to a more dynamic and application-oriented approach that prepares students for future complexities.

In reality, the mastery of mathematics among Indonesian students remains a significant concern. This is substantiated by the results from major international assessments, including the Programme for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS). PISA evaluates the abilities of 15-year-old students in reading, mathematical literacy, and science. The 2022 PISA results, involving 81 countries, placed Indonesian students at the 70th rank in mathematical literacy with a score of 366, a slight decline from the 2018 results where Indonesia ranked 73rd out of 79 countries with a score of 379. These findings indicate a persistent challenge in developing foundational mathematical competencies on an international scale, highlighting an urgent need for pedagogical reform within the national education system.

The challenges observed on the international stage are mirrored at the national and local levels. The results from Indonesia's participation in the 2015 TIMSS survey placed the nation in the 44th position out of 49 participating countries, with an average score of 397, well below the international average of 500. This issue is also evident at the school level, as seen at SMA Negeri 1 Salaman. Data from the final summative assessment for the 2023/2024 academic year revealed that the average mathematics score was still quite low. Furthermore, results from the Regency-level National Science Olympiad (OSN-K) over the past three years have been less than satisfactory, with no significant achievements recorded in the field of mathematics. This local data provides concrete evidence of the persistent struggles students face in mastering mathematical concepts.

One of the primary efforts to address this issue is the application of learning models designed to enhance creative thinking skills. However, the conventional learning process is often dominated by the teacher, positioning students as passive listeners rather than active participants (Aznaim et al., 2024). To counter this, student creativity can be effectively honed by integrating innovative learning models (Vistara, Asikin, et al., 2022). Among these, the Problem-Based Learning (PBL) model is widely recognized for its potential to improve students' creative thinking abilities. PBL emphasizes a student-centered process where learners are confronted with real-world problems that they must solve through collaboration, research, and critical discussion. This approach helps students develop essential thinking skills and promotes a deeper, more meaningful understanding of the subject matter.

Through the PBL model, students are encouraged to apply mathematical concepts in broader contexts, solve problems independently, and collaborate effectively with their peers. Research consistently shows that PBL can significantly improve critical and creative thinking skills, as the model inherently requires students to think deeply and innovatively to find solutions. The ultimate goal of PBL is to help students increase their motivation, build robust thinking skills, and become independent learners who can work together effectively in groups (Upu et al., 2022). This model is expected to empower students to take an active role in their education, fostering creativity and innovation in their approach to learning mathematics (Vistara et al., 2022; Selfiani et al., 2022).

However, even an effective model like PBL may not be sufficient on its own if it fails to account for the diverse learning needs of students. Before selecting a learning model, it is crucial to understand these individual needs. This aligns with the concept of differentiated learning, which is an effort to align the learning process with the unique requirements of each student (Gusteti & Neviyarni, 2022). According to Tomlinson (2001), student learning needs can be understood through at least three aspects: readiness, interest, and learning profile. A student's learning profile is related to various factors, including their preferred learning environment and, notably, their learning style, which dictates how they best acquire, process, and remember new information (Kusuma & Luthfah, 2022).

Understanding students' learning styles is essential for ensuring that teaching methods can accommodate every learner, making the process more effective and inclusive. Learning styles, often categorized as visual, auditory, and kinesthetic, represent the unique ways individuals prefer to interact with information (Ghufron & Risnawita, 2014; Lestari & Utami, 2023). This research offers a significant innovation by exploring the intersection of the PBL model with differentiated instruction tailored to these learning styles. While previous studies have affirmed the benefits of PBL, there is a gap in understanding how its effectiveness in fostering creative thinking skills might be moderated by students' individual learning styles. This study aims to fill that gap by examining how a differentiated PBL approach can be optimized to enhance creative thinking for all students, regardless of their preferred mode of learning.

RESEARCH METHODS

This research is a quasi-experimental research. In this study, the experiment was conducted by providing treatment in the form of implementing a learning model and will be divided into two groups, namely the experimental group and the control group. The experimental group in the learning process uses a problem-based learning model, while the control group uses direct learning. In addition to the learning model, the variables that are considered for their effects on the dependent variable are students' learning styles. The research design used is a non-equivalent control group design as shown in the following table: (Sugiyono, 2016)

Table 1. Research Design

Group	Pretest	Treatment	Posttest
EG	O_1	T_1	O_3
CG	O_2	T_2	O_4

The population in this study were all students of class XII of SMA Negeri 1 Salaman in the 2024/2025 academic year who took the elective subject of advanced mathematics consisting of 4 classes totaling 143 students. The classes used in the study were Classes F2.1, F2.2, and F2.4 because these classes have a relatively similar distribution of learning styles. Meanwhile, class F2.3 will be selected as a trial class. The data collection procedure (sampling) used in this study is purposive sampling. There are 2 classes that are the research samples, namely Phase F2.1 and Phase F2.2. Both classes were chosen for several reasons. The first consideration is that both classes have relatively the same academic abilities. The second consideration is that the number of students with the same learning style in both classes is not far apart. The first class will be given treatment in the form of learning with the PBL model which is hereinafter referred to as the experimental group (EG), while the second class uses direct learning which is hereinafter referred to as the control group (CG).

Data collection for students' learning styles is done using the documentation method because the school already has data on the learning styles of all students. Meanwhile, data

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collection for mathematical creative thinking skills is done using the test method. The mathematical creative thinking ability test is compiled based on the specific learning objectives to be achieved. Interpretation of the results of the mathematical creative thinking ability test is based on the number of items that can be answered with fluency, flexibility, originality, and the ability to detail, enrich and develop (elaboration). The collected data were then analyzed descriptively and inferentially. This study used the t-test to distinguish the average of two independent samples. Meanwhile, to determine the interaction between learning models and learning styles using two-way variance analysis or Two Way Anova.

RESULTS AND DISCUSSION

Results

This study aims to examine the effectiveness of the PBL learning model and learning styles on students' mathematical creative thinking skills. The study was conducted by giving pretest and posttest questions to grade XII students on the material of compound event probability. Before being tested in the experimental class, the researcher first tested it in a class that had received learning materials. Through testing 4 descriptive questions with the product moment correlation formula in the trial class, the following validity was obtained:

Table 2. Results of the Validity Test of the Trial Instrument

Question items	r count	r table	Conclusion	Category
Item 1	0,615	0,329	Valid	High
Item 2	0,742	0,329	Valid	High
Item 3	0,727	0,329	Valid	High
Item 4	0,606	0,329	Valid	High

Of the 4 questions tested, all were valid at a significance level of 5%. Furthermore, for the reliability of the questions using the Cronbach's Alpha method, the following results were obtained:

Table 3. Results of Instrument Trial Reliability Test

Reliability Statistics	
Cronbach's Alpha	N of Items
.573	4

From the reliability test, the calculated r value = 0.573 was obtained. By comparing the r table = 0.329, then the calculated r value = 0.573 > r table = 0.329 so that the instrument is declared reliable in the moderate category. Thus, 4 questions are declared valid and reliable, so they can be used for research. Next is the normality test for the posttest value with the provision that the data is normally distributed if the Sig. Shapiro-Wilk value is above 0.05. The results are presented in Table 4.

Table 4. Normality Test Results

Tests of Normality							
		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Model_pembelajaran	Statistic	df	Sig.	Statistic	df	Sig.
Posttest_score	Problem based learning	.146	35	.057	.945	35	.077
	Direct learning	.146	36	.052	.950	36	.108

Based on the results of the Shapiro-Wilk normality test, the significance value for the experimental class with the PBL model was 0.077 and for the control class with the direct learning model was 0.108. Both are greater than the significance level set at $\alpha = 0.05$. Thus, the

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posttest data (variable Y) comes from a population that is normally distributed at a significance level of 0.05. The next step is the homogeneity test which aims to ensure equality of variance between the posttest values of the experimental group and the control group. The findings of the homogeneity test results are presented in Table 5.

Table 5. Homogeneity Test Results

Levene's Test of Equality of Error Variances[a,b]

		Levene Statistic	df1	df2	Sig.
Posttest_score	Based on Mean	.423	5	65	.831
	Based on Median	.468	5	65	.799
	Based on Median and with adjusted df	.468	5	61.503	.799
	Based on trimmed mean	.446	5	65	.815

The results of the homogeneity test based on the average (Based on Mean) obtained a significance of = 0.831. This value is greater than the set significance level $\alpha = 0.05$ ($0.831 > 0.05$), thus both experimental groups have homogeneous variances. Furthermore, a hypothesis test was carried out, namely a two-way variance analysis test (two-way anova) assisted by IBM SPSS Statistics 25 with the following results.

Table 6. Two Way Anova Test Results

Tests of Between-Subjects Effects

Dependent Variable: Posttest_score

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3139.433[a]	5	627.887	3.496	.007
Intercept	361016.045	1	361016.045	2010.057	.000
Learning_model	1917.732	1	1917.732	10.678	.002
Learning_style	780.547	2	390.274	2.173	.122
Learning _model * Lerning_style	516.558	2	258.279	1.438	.245
Error	11674.316	65	179.605		
Total	377571.889	71			
Corrected Total	14813.749	70			

Based on Table 6 above, we get:

1. Learning Model Factors (variable X1)

In this study, the learning model factor consists of two sub-factors, namely the PBL model and the direct learning model. The results of the analysis of variance between the two learning models obtained a p-value = 0.002 at a significance level of 0.05. Because the p-value < 0.05 means that there is a difference in the average posttest results of students who were treated with the PBL model and students who were taught with the direct learning model. To see the effectiveness of the two learning models, they were analyzed again using the T test. The results obtained are as follows:

Table 7. T Test Results

Independent Sample Test

	Levene Test for Equality of Variances	t-test for Equality of Means

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		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of The Difference	
									Lower	Upper
Posttest_score	Equal variances assumed	.002	.964	3.145	69	.002	10.23130	3.25279	3.74217	16.72044
	Equal variances not assumed			3.147	68.999	.002	10.23130	3.25163	3.74448	16.71812

From the table above, it can be seen that there is a difference in the average value (Mean Difference) between the results of the posttest of students with the PBL model and the results of the posttest with the direct learning model = 10.23130. Thus, learning with the PBL model provides better results than the direct learning model on the material of compound event probability at SMA Negeri 1 Salaman Magelang. This result is also supported by the descriptive statistical values of the data from the two groups as follows:

Table 8. List of Descriptive Statistical Values of Learning Models

Learning Model	Descriptive Statistics Values								
	Sum	Max	Min	Range	Mean	Median	Mode	Variance	Standard Deviation
PBL	2683,34	100,00	50,00	50,00	76,67	75,00	75,00	183,01	13,53
Direct Learning	2391,68	91,67	41,67	50,00	66,44	66,67	66,67	192,39	13,87

In the PBL model student group, the average value of mathematical creative thinking ability was 76.67 with a standard deviation of 13.53, which was greater than the average value in the direct learning model student group, which was 66.44 with a standard deviation of 13.87. This is in line with the research of Damayanti et al., (2020), the group of students who learned with the PBLFC model had significantly higher creative thinking abilities compared to the group of students who learned with the DI model.

2. Learning Style Factors (variable X2)

In this study, the student learning style factor consists of 3 sub-factors, namely auditory learning style, kinesthetic learning style and visual learning style. The results of the variance analysis of learning styles in Table 6 above show that at a significance level of 0.05, a p-value (Sig. = 0.122) is obtained, thus the p-value> 0.05. Thus H_0 is accepted and H_1 is rejected. Almost the same results are shown in the following table:

Table 9. Pairwise Comparison of Student Learning Styles

Multiple Comparisons
Dependent Variable: Posttest_score
Tukey HSD

(I) Learning_style	(J) Learning_style	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Auditory	Kinesthetic	-6.8722	3.96696	.201	-16.3872	2.6428
	Visual	-5.9996	3.79057	.260	-15.0915	3.0923
Kinesthetic	Auditory	6.8722	3.96696	.201	-2.6428	16.3872
	Visual	.8726	3.96696	.974	-8.6424	10.3876
Visual	Auditory	-5.9996	3.79057	.260	-3.0923	15.0915
	Kinesthetic	.8726	3.96696	.974	-10.3876	8.6424

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The average difference (Mean Difference) per pair according to student learning styles (auditory, kinesthetic, and visual) there is a difference in the average value but the p-value (Sig.) > 0.05 so that the difference is not significant. This means that the learning style variable cannot significantly differentiate the posttest results obtained by students. From the results of the analysis in Table 6 above, it can be concluded that the second hypothesis H_0 is accepted and H_1 is rejected. It can be concluded that there is no significant difference in posttest results between students with different learning styles. In other words, differences in learning styles (auditory, kinesthetic, visual) cannot differentiate the ability to think creatively in mathematics in learning the probability of compound events at SMA Negeri 1 Salaman Magelang This is also in accordance with the research results presented by Wanelly & Fauzan, (2020) namely there is no difference in creative thinking ability between auditory, visual and kinesthetic learning styles. The difference in students' mathematical creative thinking ability is not because of how students learn but is largely determined by the activeness of a student's learning. Students who are active in learning whatever their learning style will provide positive results for their mathematical creative thinking ability.

3. Interaction Between Learning Model Factors and Learning Styles (X1*X2)

The results of the analysis of variance of the interaction of learning model factors and learning styles (X1*X2) as shown in Table 6 above at a significance level of 0.05 obtained a p-value (Sig. = 0.245). Because the p-value > 0.05 for the third hypothesis H_0 is accepted or H_1 is rejected, so there is no interaction between learning models and learning styles. The average results of the factorial experiment between learning model factors and students' learning styles are presented in the following table

Table 10. Average Results of Factorial Experiments Between Learning Models and Learning Styles

Learning Model (X1)	Learning Style (X2)		
	Auditory	Kinesthetic	Visual
Problem-based Learning	75,642	79,166	75,694
Direct Learning	58,333	69,697	71,155
Difference	17,309	9,469	4,539

From the table above, it can be seen that the influence of learning model factors and learning style factors are not the same on the difference in average values. The difference in the influence of learning models and learning style factors is as follows: auditory learning style of 17.309; kinesthetic learning style of 9.469; and visual learning style of 4.539. When presented in graphic form, the following graph is obtained:

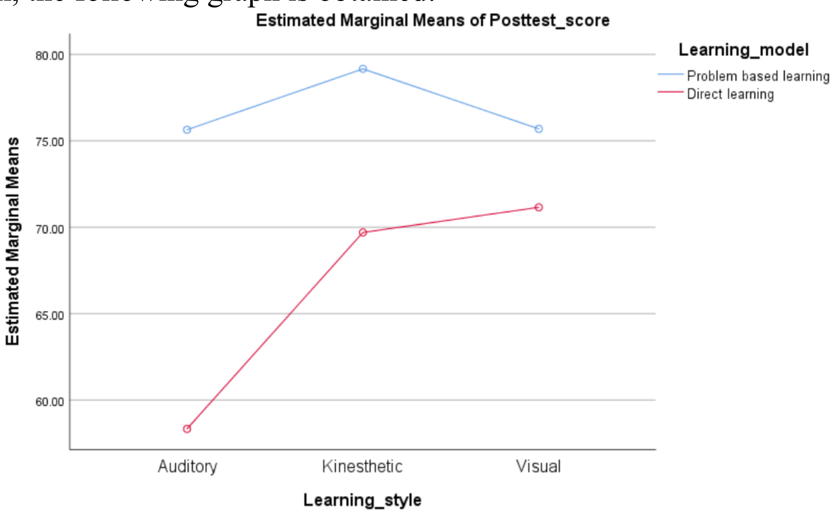

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Figure 1. Interaction of Learning Models and Learning Styles

From the picture, it can be seen that the posttest results of the PBL model are better than the posttest results of the direct learning model regardless of the learning style. Or in each learning style (auditory, kinesthetic, and visual) the mathematical creative thinking ability of students who follow the PBL model is better than those who follow the direct learning model. Based on the analysis, there is no significant interaction between learning model factors (PBL and direct learning) and learning style factors (auditory, kinesthetic, visual) on students' mathematical creative thinking abilities in learning about the probability of compound events at SMA Negeri 1 Salaman Magelang. The results of this study are also in line with research Suhaena et al., (2017) that there is no significant interaction effect between learning models and learning styles on creative mathematical thinking skills.

Discussion

This study's findings provide compelling evidence that the choice of instructional model significantly impacts students' mathematical creative thinking skills. The primary analysis, a two-way *ANOVA*, revealed a statistically significant main effect for the learning model, with a *p-value* of .002, which is well below the .05 alpha level. This indicates a substantial difference in posttest outcomes between students taught using the *Problem-Based Learning* (PBL) model and those taught with a direct learning model. A subsequent independent samples *t-test* further clarified this difference, showing a mean difference of 10.23 in favor of the PBL group. The descriptive statistics corroborate this, with the PBL group achieving a higher average score (76.67) compared to the direct learning group (66.44). This robust evidence suggests that the PBL model, by its very nature of engaging students in authentic problem-solving, is a more effective pedagogical approach for fostering the higher-order cognitive abilities required for creative thinking in mathematics.

In contrast to the strong effect of the learning model, the study found no significant main effect for learning styles on students' creative thinking abilities. The analysis of variance yielded a *p-value* of .122, which is greater than the .05 significance level, leading to the acceptance of the null hypothesis. This suggests that whether a student identifies as having an auditory, kinesthetic, or visual learning style does not, in itself, predict their performance on the mathematical creative thinking posttest. The pairwise comparisons further confirmed this, showing no significant differences between any of the learning style groups. This finding aligns with the research presented by Wanelly and Fauzan (2020), which also found no significant difference in creative thinking ability among students with different learning styles. It implies that the mechanism for developing creative thinking is less about the modality of information intake and more about the cognitive processes activated during learning.

Furthermore, the analysis revealed no significant interaction effect between the learning model and students' learning styles, with a *p-value* of .245. This is a critical finding, as it indicates that the effectiveness of the PBL model was consistent across all three learning style groups (auditory, kinesthetic, and visual). The interaction plot visually demonstrates that while the PBL group consistently outperformed the direct learning group, the lines representing the learning styles run nearly parallel, signifying no synergistic or antagonistic effect. The PBL model did not disproportionately benefit one learning style over another; its positive impact was universal within the context of this study. This result is consistent with prior research by Suhaena et al. (2017), which also reported a lack of significant interaction between learning models and learning styles on creative mathematical thinking, suggesting PBL's robust applicability.

The Problem-Based Learning (PBL) model has emerged as a significant pedagogical approach that fosters enhanced mathematical creative thinking among students, irrespective of their inherent learning style preferences. This model is characterized by presenting ill-structured problems that require students to engage in inquiry and emphasize collaborative solution-finding. Such an environment has been demonstrated to stimulate key components of creative thinking, namely cognitive flexibility, fluency, and originality. Research findings indicate that learning models that encourage collaborative efforts and creative problem-solving significantly bolster students' creative thinking skills. For example, Winarko's work indicates that project-based learning can effectively improve students' creative thinking abilities through meaningful tasks (Winarko, 2024). Similarly, Muawiyah argues that collaborative learning frameworks, specifically the Creative Collaborative (CC) model, enhance students' creative capacities, reinforcing that engagement transcends individual learning preferences (Muawiyah, 2024).

Studies have found that PBL's effectiveness is not contingent upon students' preferred learning styles but rather on the active involvement required in cognitively demanding tasks. Hidayah and Dwijanto document that PBL not only elevates students' creative problem-solving capabilities but also encourages a deeper engagement with mathematical concepts, positively shaping students' overall learning experiences (Hidayah & Dwijanto, 2023). Furthermore, research indicates that when students are immersed in tasks with significant cognitive demands, their preferred modalities of learning become secondary (Tan et al., 2020), emphasizing that the process of knowledge construction under PBL conditions is key for fostering creativity. Moreover, the integration of STEM within PBL frameworks has gained traction as an effective strategy for promoting mathematical creative thinking. Hidayah and Evendi support the notion that STEM-integrated PBL models enhance students' capabilities to navigate complex mathematical problems, thereby boosting their creative thinking (Hidayah & Dwijanto, 2023). By aligning educational practices with innovative pedagogical strategies like PBL, educators can catalyze significant shifts in students' cognitive engagement, ultimately driving better academic outcomes.

The implications of this research for educational practice are profound. It suggests that educators seeking to cultivate creative thinking skills should prioritize the implementation of active, student-centered pedagogical models like PBL over attempts to tailor instruction to individual learning styles. While acknowledging students' preferences is important for engagement, the more impactful strategy for developing higher-order thinking is to design authentic, problem-based learning experiences. This study provides empirical support for shifting instructional focus from *how* students receive information (auditory, visual, kinesthetic) to *what* students do with that information (analyze, synthesize, create, solve). This aligns with the findings of Damayanti et al. (2020), reinforcing that active learning models are superior for developing creative thinking compared to more passive, direct instruction approaches.

However, it is essential to acknowledge the limitations of this study. The research was conducted with a specific population (grade XII students) in a single school and focused on a single mathematical topic (compound event probability), which may limit the generalizability of the findings. Furthermore, the reliability of the research instrument, while acceptable, was in the moderate range with a *Cronbach's Alpha* of .573. A higher reliability score would lend greater confidence to the consistency of the measurements. Future research could address these limitations by replicating the study with a larger, more diverse sample across different schools and subject areas. Investigating the long-term effects of PBL on creative thinking and exploring the role of teacher facilitation within the PBL framework would also be valuable avenues for further inquiry.

In conclusion, this study makes a significant contribution by demonstrating the superior effectiveness of the *Problem-Based Learning* model over direct instruction in fostering students' mathematical creative thinking skills. The findings robustly indicate that the pedagogical approach is a more critical factor than students' individual learning styles. There was no evidence to suggest that learning styles (auditory, kinesthetic, or visual) or their interaction with the teaching model had a significant impact on the outcomes. Therefore, this research strongly advocates for the broader adoption of active, problem-centered learning methodologies in mathematics education. The clear implication is that to develop the creative problem-solvers needed for the 21st century, the focus must be on engaging students in authentic intellectual work, a task for which PBL is exceptionally well-suited.

CONCLUSION

Based on the results of the research and discussion, it can be concluded that the effectiveness of the problem-based learning model and learning styles on the mathematical creative thinking skills of students at SMA Negeri 1 Salaman Magelang on the subject of compound event probability is as follows. First, students who follow the PBL model have better mathematical creative thinking skills compared to students who follow the direct learning model. Second, there is no difference in the mathematical creative thinking skills of students with different learning styles. Third, there is no significant interaction effect between the learning model (PBL and direct learning) and students' learning styles (auditory, kinesthetic, visual) on mathematical creative thinking skills.

REFERENCES

Aznaim, A., et al. (2024). Pengaruh model pembelajaran Problem Based Learning dan model pembelajaran langsung terhadap hasil belajar matematis siswa pada materi barisan aritmetika di kelas X. *Innovative: Journal of Social Science Research*, *4*(1), 10833–10844.

Damayanti, S. A., et al. (2020). Pengaruh model Problem Based Learning dengan Flipped Classroom terhadap kemampuan berpikir kreatif. *Jurnal Kependidikan*, *4*(1), 83–98.

Ghufron, M. N., & Risnawita, R. (2014). *Gaya belajar: Kajian teoritik*. Pustaka Pelajar.

Gusteti, M. U., & Neviyarni, N. (2022). Pembelajaran berdiferensiasi pada pembelajaran matematika di Kurikulum Merdeka. *Lebesgue: Jurnal Ilmiah Pendidikan Matematika, Matematika dan Statistika*, *3*(3), 636–646. https://doi.org/10.46306/lb.v3i3.180

Hidayah, K., & Dwijanto, D. (2023). Mathematical creative thinking ability viewed by adversity quotient in problem-based learning integrated STEM. *Unnes Journal of Mathematics Education*, *12*(1), 72–83. https://doi.org/10.15294/ujme.v12i1.67560

Kusuma, O. D., & Luthfah, S. (2022). *Praktik pembelajaran yang berpihak pada murid*. Kementerian Pendidikan, Kebudayaan, Riset dan Teknologi.

Lestari, E. P., & Utami, N. (2023). Analisis kemampuan komunikasi matematis tertulis siswa berdasarkan gaya belajar siswa. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, *7*(3), 2501–2516. https://doi.org/10.31004/cendekia.v7i3.2315

Muawiyah, S. (2024). Fostering creative and critical thinking skills through collaborative learning: A theoretical approach. *International Summit and Conference on Education, Social Sciences, and Humanities*, *1*(1), 612–620. https://doi.org/10.21009/isc-beam.011.43

Selfiani, S., et al. (2022). Pengaruh model Problem Based Learning terhadap kemampuan berpikir kreatif matematis siswa pada materi kubus dan balok. *Research in the Mathematical and Natural Sciences*, *1*(2), 30–36. https://doi.org/10.55657/rmns.v1i2.66

Sugiyono. (2016). *Metode penelitian kuantitatif, kualitatif, dan R&D*. Alfabeta.

Suhaena, S., et al. (2017). Pengaruh pembelajaran berbasis problem solving dan gaya belajar terhadap kemampuan berpikir kreatif matematika siswa SMP. *Jurnal Pembelajaran Berpikir Matematika*, *2*(2), 21–32.

Tan, S., et al. (2020). Improving student creative thinking ability with problem based learning approach using Hawgent dynamic mathematics software. *Journal on Education*, *2*(4), 303–312. https://doi.org/10.31004/joe.v2i4.324

Tomlinson, C. A. (2001). *How to differentiate instruction in mixed-ability classrooms*. Association for Supervision and Curriculum Development.

Upu, H., et al. (2022). *Problem based learning dalam pembelajaran matematika*. Global-RCI.

Vistara, M. F., et al. (2022). Problem based learning berorientasi STEM context terhadap kemampuan berpikir kreatif matematika siswa. *PRISMA, Prosiding Seminar Nasional Matematika 5*, 451–460.

Wanelly, W., & Fauzan, A. (2020). Pengaruh pendekatan open-ended dan gaya belajar siswa terhadap kemampuan berpikir kreatif matematis. *Jurnal Basicedu*, *4*(3), 523–533.

Winarko, G. (2024). Project-based learning with scratch to improve students' creative thinking ability: Systematic literature review. *Griya Journal of Mathematics Education and Application*, *4*(2), 190–196. https://doi.org/10.29303/griya.v4i2.440