Pasundan Journal of Mathematics Education Volume 16, No. 1, 2026, pp. 40-51

Mathematical literacy in problem-based learning viewed from cognitive styles

Yusfita Yusuf[1*], Mimih Aminah[2], Yuni Nurfitriani[3], Kurram Shabbir[4]

[1, 2]Universitas Sebelas April, Sumedang, Indonesia
[3]SMP Negeri 1 Ganeas, Sumedang, Indonesia
[4]Abdus Salam School of Mathematical Sciences, Lahore, Pakistan

*Email: yusfita@unsap.ac.id

Abstract

The mathematical literacy ability of students in Indonesia remains low. One contributing factor is classroom learning activities that are primarily limited to the transfer of knowledge. Additionally, during the learning process, students with different cognitive styles are suspected to have varying levels of understanding of the same concept. The problem-based learning (PBL) model not only actively involves students but also provides them with opportunities to develop their abilities and foster critical thinking. Hence, this research seeks to explore the interplay between the Project-Based Learning model and cognitive styles in relation to students' mathematical literacy abilities. This quantitative study employed a factorial research design. The subjects comprised 64 junior high school students in Sumedang. Prior to the commencement of the learning process, students completed the Group Embedded Figures Test (GEFT) to identify their cognitive styles. Following this, the experimental class was taught using the Project-Based Learning model, while the control class received conventional instruction over a three-week period. After the learning sessions, students were tested on their mathematical literacy skills. Data analysis was conducted using a two-way ANOVA. The results indicated that an interaction effect was observed between the learning model and cognitive style, influencing students' mathematical literacy skills.

Keywords: cognitive style, field-dependent, field-independent, mathematical literacy; problem-based learning

How to Cite: Yusuf, Y., Aminah, M., et.al. (2026). Mathematical literacy in problem-based learning viewed from cognitive styles. *Pasundan Journal of Mathematics Education, 16*(1), 40-51. http://doi.org/ 10.23969/pjme.v16i1.35172

INTRODUCTION

The 21st century marks the beginning of the third millennium, characterized by advancements in global competition, science and technology, and free-market competition (Janah et al., 2019). According to (Retnawati et al., 2024) students must possess several critical skills, including mathematical literacy, to thrive in the 21st century. Several scholars define mathematical literacy as the capacity to understand and apply mathematical concepts effectively in daily life situations (Muslimah & Pujiastuti, 2021; Muzaki & Masjudin, 2019; Setyaningsih & Munawaroh, 2022). Furthermore, (Mansur, 2018) suggests that

© the Author(s) 2026
This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License
http://doi.org/10.23969/pjme.v16i1.35172

individuals with strong literacy skills can make predictions, interpret data, solve real-life problems, reason numerically, graphically, and geometrically, and communicate effectively using mathematics. Mathematical literacy is defined as the ability to formulate, apply, and interpret mathematical concepts across a variety of contexts.

Mathematical literacy is crucial for students to address and overcome the challenges of modern life. According to the Organisation for Economic Co-operation and Development (OECD, 2023), mathematical literacy refers to students' ability to apply mathematics in real-world contexts and reason mathematically based on concepts and procedures. The Programme for International Student Assessment (PISA) scores provide insight into the state of mathematical literacy among students in Indonesia. (Retnawati et al., 2024) summarized a decade of PISA results, highlighting the need for significant improvement in Indonesian students' mathematical literacy.

Hendroanto et al. (2018) identify classroom learning methods as a major factor contributing to the low mathematical literacy among students, where teaching is often limited to knowledge transfer from teachers to students. Learning that focuses solely on knowledge transfer tends to position students as passive recipients, thus providing them with fewer opportunities to construct understanding, develop reasoning, and relate mathematical concepts to real-world contexts. As a result, mathematical literacy skills, which require problem-solving, communication, and critical reflection, do not develop optimally. Besides learning, students' internal factors also influence mathematical literacy skills. One of these is their cognitive style (Nurfitriani et al., 2024). Students who have a certain cognitive style are thought to have a different level of understanding than students who have another cognitive style regarding the same concept in a particular learning model (Wijaya, 2016). Cognitive style refers to an individual’s approach to gathering and processing information, their attitude toward the information obtained, and their behavior in a learning environment (Alghofiqi et al., 2020). Thus, a learning model is needed that not only facilitates the transfer of knowledge but also guides students to construct their understanding and develop their skills.

In implementing the learning model, of course, the diversity of students' cognitive styles needs to be taken into consideration because the suitability between students' cognitive characteristics and learning strategies can influence the depth of understanding of concepts. The findings suggest that the PBL model is an effective and promising approach to improving mathematical literacy when implemented with attention to relevant contextual and learner-specific factors (Gufron et al., 2025). PBL places contextual problems as the starting point for learning, encouraging students to understand situations, formulate mathematical problems, choose solution strategies, and communicate their results. This process directly aligns with the key components of mathematical literacy, such as mathematization, reasoning, representation, and problem-solving in real-world contexts (Gufron et al., 2025; Izzati et al., 2025; Yani et al., 2025). However, the effectiveness of PBL in developing mathematical ability is inseparable from differences in students' cognitive styles (Habeahan et al., 2025). Cognitive styles influence how students receive information, organize knowledge, and process problems (Setiawan et al., 2020; Surur et al., 2020). When a student faces a problem, their cognitive style will determine how they process it information differently (Nurfitriani et al., 2024). Thus, PBL serves as a potential pedagogical context for developing mathematical literacy, while cognitive style acts as an internal factor that moderates students' success in utilizing the learning experience.

Problem-Based Learning has been widely recognized as an effective instructional approach for improving students’ mathematical literacy. Previous studies consistently report that the implementation of PBL can significantly enhance students’ ability to formulate, apply, and interpret mathematics in various contexts (Huda & Khotimah, 2023). Despite these findings, most existing research primarily examines the effectiveness of PBL in general terms and tends to overlook the role of individual cognitive characteristics that may influence students' learning processes and outcomes. In particular, limited studies have explored mathematical literacy development in PBL environments from the perspective of students' cognitive styles. Cognitive style represents a relatively stable characteristic that shapes how individuals perceive, process, and organize information (Yusuf & Sukestiyarno, 2022). Among various cognitive style dimensions, field-dependent and field-independent styles have been widely investigated because they reflect differences in analytical ability and information processing strategies in learning situations (Farmaki et al., 2019). Although several studies have examined literacy skills in problem-based learning settings from the perspective of visualizer and verbalizer cognitive styles (Rahayu et al., 2021) empirical evidence regarding the interaction between PBL and field-dependent and field-independent cognitive styles in shaping students' mathematical literacy remains limited. Therefore, this study aims to address this gap by examining whether an interaction exists between the PBL model and students' cognitive styles in enhancing mathematical literacy skills. By integrating instructional and cognitive perspectives, this research is expected to provide deeper insights into how individual cognitive characteristics influence the effectiveness of problem-based learning in mathematics education.

METHODS

This research utilized a quantitative approach with a 2 × 2 factorial design. The factorial design was selected to examine not only the direct effects of the independent variables on the dependent variable but also the interaction effects between the two independent variables on the dependent variable. The study was conducted among seventh-grade students at a public junior high school in Sumedang Regency. The sample included 32 students from Class VII A as the experimental group, which implemented the Problem-Based Learning model, and 32 students from Class VII B as the control group, which followed conventional direct teaching methods. The research design can be seen in the figure 1.

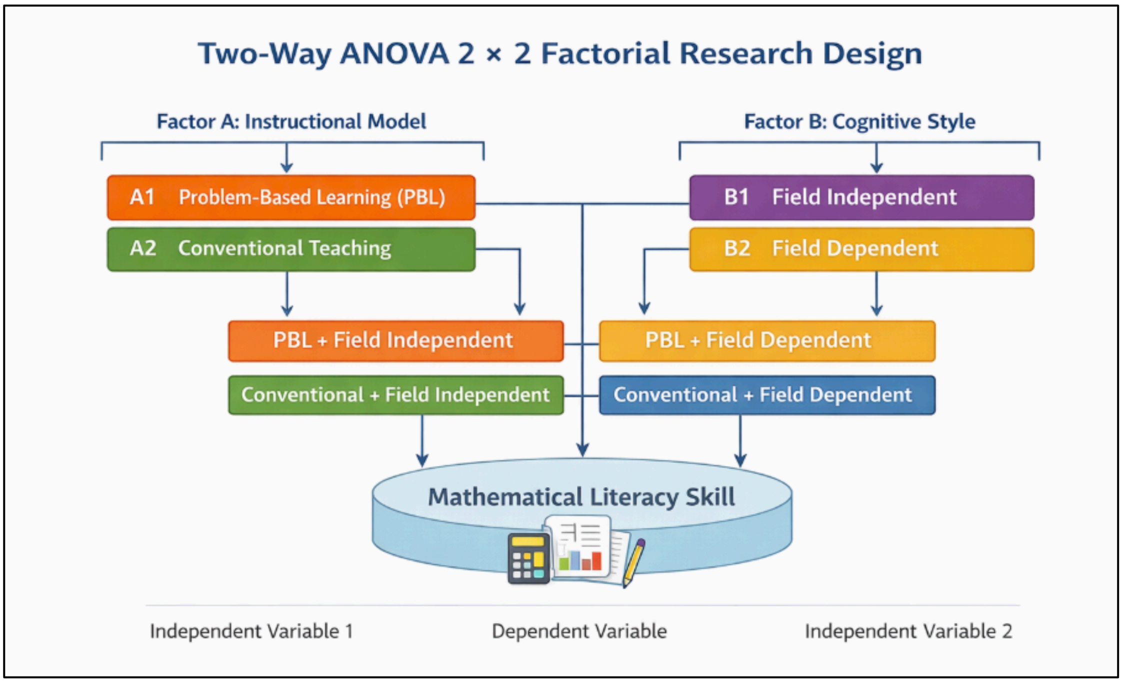

Figure 1. Research Design

The instruments utilized in this study consisted of the Group Embedded Figures Test (GEFT) to identify students' cognitive styles and a mathematical literacy test to measure their proficiency in mathematical literacy. The GEFT is an instrument or tool commonly used to test a person's cognitive level by searching for simple images from complex ones. The GEFT contains 25 complex images, divided into three sections, each with a maximum of 15 minutes to complete. Section 1 is a practice section containing 7 complex images, while the second and third sections are both exam and research sections, each containing 9 complex images. The GEFT used in this study was developed by Herman A. Witkin et al., with only language adjustments made. The GEFT was administered before the learning sessions commenced, while the mathematical literacy test was given after the learning sessions were completed. To classify students' cognitive styles, a scoring rule was applied: students scoring between 0 and 9 were categorized as having a field-dependent (FD) cognitive style, while those scoring above 9 to 18 were categorized as having a field-independent (FI) cognitive style.

The mathematical literacy test comprised three essay questions. These questions were developed by researchers based on the OECD (OECD, 2019) mathematical literacy indicators, which include communication skills, mathematization, representation, reasoning, selection of problem-solving strategies, use of formal language and symbols, and utilization of mathematical tools. The questions were validated by one junior high school mathematics teacher and two mathematics education lecturers. The teacher validator's qualifications were a minimum of a Master's degree in mathematics education and at least five years of teaching experience. The mathematics education lecturer's qualifications were a Doctorate in mathematics education and at least five years of teaching experience. The results of the mathematical literacy test were analyzed quantitatively using two-way ANOVA by first testing the prerequisites, namely the normality and homogeneity tests.

RESULTS AND DISCUSSION

The GEFT test was conducted with both the experimental and control groups, comprising 64 students. The cognitive style scores of the students are presented in Table 1.

Table 1. Cognitive Style Classification

Cognitive Style	Learning Model	
	PBL	Direct
FI	10	11
FD	22	21
Total	32	32

Table 1 shows that 43 students from the seventh grade at SMP Negeri 1 Ganeas exhibited a field-dependent cognitive style, while 21 students demonstrated a field-independent cognitive style. This indicates that the majority of students in this grade level require external support for motivation and learning comprehension.

After the GEFT test and pre-test, learning was conducted using problem-based instruction in the experimental class and conventional learning models in the control class. Learning with the PBL model begins by presenting a phenomenon, demonstration, or story to raise a problem, motivating students to engage in solving their chosen problem. After that, the teacher helps students define and organize learning tasks related to the problem. The teacher encourages students to gather appropriate information and conduct experiments to obtain explanations and solutions to the problem. The teacher assists students in planning and preparing appropriate work and helps them share their assignments with their friends. And the final activity is the teacher helps students reflect on or evaluate their investigations and the processes they use. After three learning meetings, a mathematical literacy test (pos-test) is administered. The results of the descriptive analysis are presented in Table 2.

Table 2. Deskriptive Analysis

Gaya Kognitif	Class	Mean	Std. Deviation	N
FI	Experimental	95.1111	8.37163	9
	Control	73.5000	7.26101	10
	Total	83.7368	12.56026	19
FD	Experimental	78.5652	10.53358	23
	Control	46.5455	11.76244	22
	Total	62.9111	18.52986	45
Total	Experimental	83.2188	16.15365	32
	Control	54.9688	16.43655	32
	Total	69.0938	19.41258	64

The mathematical literacy test scores of both the experimental and control groups were first subjected to a normality test as a prerequisite for subsequent analyses. The results are presented in Figure 2 and 3.

Table 3. Normality Test Result for the Experimental and Control Group

	Kolmogorov-Smirnov[a]		
	Statistic	**Df**	**Sig.**
Experimental	0.146	32	0.079
Control	0.148	32	0.71

According to Table 2 and 3, the normality test results indicate that the data from the experimental group had a significance value of 0.079 (> 0.05) according to the Kolmogorov-Smirnov test, and the control group had a significance value of 0.071 (> 0.05) according to the Kolmogorov-Smirnov test. Thus, the null hypothesis is accepted, suggesting that the mathematical literacy test scores for both groups follow a normal distribution. Next, a homogeneity test was carried out as a requirement for conducting a two-way ANOVA analysis. The result are presented in Table 4.

Table 4. Homogeneity Test

	Levense's Test of Equality of Error Variances[a,b]			
	Lavene Statistic	**df1**	**df2**	**Sig.**
Based on Mean	2.832	3	60	0.056
Based on Median	2.610	3	60	0.060
Based on Mean and with adjusted df	2.610	3	58.123	0.060
Based Trimmed mean	2.871	3	60	0.54

According to Table 4, the homogeneity Test result indicate that the significance value of 0.056 (>0,05) based on mean. Thus, the null hypothesis is acceptes,suggesting that the variance of data between groups is homogeneous (the same).

Since the data are normally distributed and homogeneous, further analysis using a two-way ANOVA was conducted. The result are presented in Table 5.

Table 5. Two-Way ANOVA Result

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	19534.942[a]	3	6511.647	92.880	.000
Intercept	287532.860	1	287532.860	4101.269	.000
Cognitive Style	6306.704	1	6306.704	89.957	.000
Learning Model	9586.165	1	9586.165	136.734	.000
Cognitive Style * Learning Model	361.081	1	361.081	5.150	.027
Error	4206.496	60	70.108		
Total	329274.000	64			
Corrected Total	23741.438	63			

R Squared = .823 (Adjusted R Squared = .814)

Based on the results of the two-way ANOVA test in Table 5, the data shows a significant difference of 0.000 (<0.05) for the Cognitive Style source, thus rejecting H0. Therefore, the average mathematical literacy scores of students with the FI cognitive style and those with the FD cognitive style are significantly different. To determine which is better, we can examine the average post-test scores for mathematical literacy skills for each cognitive style, as shown in Figure 1. The average mathematical literacy scores for students with the FI cognitive style in both the experimental and control classes are higher than those for students with the FD cognitive style. Therefore, it can be concluded that students with the FI cognitive style have better mathematical literacy skills than those with the FD cognitive style (Hypothesis 1).

Furthermore, note the sign value for the Learning Model source, which is 0.000 (0.05), thus rejecting H0. So the average mathematical literacy scores of students in the experimental class and the control class are significantly different. To find out which one is better, it can be seen from the average post-test score of mathematical literacy abilities. Where the average mathematical literacy score in the experimental class is 83.2188 greater than the average mathematical literacy score in the control class, which is 54.9688. Thus, it can be concluded that students who receive PBL have better mathematical literacy abilities than students who receive direct learning (Hypothesis 2). The results of the two-way ANOVA analysis on the source of cognitive style * class, show a sign value. 0.027 (<0.05) so that H0 is rejected. So there is an interaction effect between the learning model and cognitive style on students' mathematical literacy abilities (Hypothesis 3).

Based on the results of the mathematical literacy test, students with the FI cognitive style obtained higher scores than students with the FD cognitive style. This is in line with the results of previous research. In a study conducted by (Wulan & Anggraini, 2019) also stated that FI subjects were better at the Polya problem-solving profile than FD subjects. In addition, the results of research by (Amini et al., 2023) also showed that students with the Field Independent (FI) cognitive style type were able to solve problems better and had a higher level of mathematical creative thinking ability than students with the Field Dependent (FD) cognitive style type. The results of research by (Shiddieqy et al., 2023) showed that students with high mathematical connection abilities were generally students with the Field Independent (FI) cognitive style. Students with the FI cognitive style had better mathematical abilities compared to students with the FD cognitive style. This occurs because students with an FI cognitive style remember more easily and have stronger memories (Ginting & Nasution, 2024; Suhaji et al., 2020). Furthermore, explain that differences in cognitive styles have implications for individual differences in receiving, remembering, organizing, processing, thinking, and solving problems. Within cognitive styles, there are different ways of viewing, recognizing, and organizing information (Eka et al., 2014).

The core competencies of mathematical literacy are being able to formulate problems mathematically, being able to use concepts, facts, procedures, and reasoning in mathematics, as well as interpreting, applying, and evaluating the results of a mathematical process (OECD, 2010). Someone with a field-independent cognitive style will have an easier time having these competencies because they easily face tasks that require differences and analysis (Ikhlas, 2018; Suyuti et al., 2023). The character of an individual who has this FI cognitive style will have an easier time understanding concepts, this is because students are said to have a deep conceptual understanding if the student can reconstruct the meaning of a concept themselves, interpret it and know its relationship with other concepts in solving a problem faced (Eka et al., 2014). In contrast to someone who has a cognitive style, where the person needs motivation and reinforcement from outside (Suyuti et al., 2023). So someone with a field-dependent cognitive style needs the help of others in developing mathematical literacy skills.

Based on the analysis, it was found that students who received PBL learning had better mathematical literacy skills than students who received direct learning. The results of this study are in line with the results of research by (Nurlaela & Imami, 2022; Prihatiningtyas & Buyung, 2023; Purnama et al., 2023; Subaryo, 2022) which showed that the PBL model was better at improving mathematical abilities compared to conventional learning or direct learning. This is in accordance with the opinion of (Haryadi et al., 2021) that if teachers want students to learn to discover concepts and practice higher-order thinking skills, the direct learning model is less suitable. Furthermore, (Junaidi, 2018) stated that if students want to find out the essence of information (conceptual skills), this is through indirect learning, where in indirect learning the teacher provides information through problems that need to be solved by the students. Mathematical literacy is one of the higher-order thinking skills, so with direct learning, mathematical literacy skills will not develop optimally.

The problem-based learning learning model is a student-centered learning model (Ali, 2019; Nicholus et al., 2023). The role of teachers in PBL is to present problems, ask questions and facilitate investigation and dialogue (Mumu et al., 2025). Pimdee et al. (2024) and Salam et al. (2024) explain that the role of teachers is to guide students in breaking down problem-solving plans into stages of activity; teachers provide examples of the use of skills and strategies needed so that these tasks can be completed. The role of teachers in PBL is in line with the core competencies of mathematical literacy stated by PISA (OECD, 2010) namely being able to formulate problems mathematically, being able to use concepts, facts, procedures, and reasoning in mathematics, and interpreting, applying, and evaluating the results of a mathematical process. Thus, through PBL which provides many non-routine problems that students rarely encounter in classroom learning, problem-solving skills can be improved, which is one of the parts that is the focus of mathematical literacy (OECD, 2013).

The findings of this study reveal a significant interaction effect between the learning model and cognitive style on students' mathematical literacy skills. This indicates that the effectiveness of the instructional approach is not uniform across all learners but is contingent upon students' cognitive characteristics. Such results reinforce the perspective that learning outcomes are shaped by the alignment between instructional design and individual cognitive processing patterns, rather than by the instructional model alone. Previous studies have similarly reported that instructional strategies and cognitive styles jointly influence students' mathematical performance, highlighting the conditional nature of learning effectiveness (Zhang & Sternberg, 2005)

From a cognitive perspective, field-dependent (FD) and field-independent (FI) learners differ fundamentally in how they perceive, organize, and process information. FI students tend to demonstrate stronger analytical abilities, particularly in identifying relevant information within complex or ambiguous contexts, whereas FD students are more reliant on external structures and guidance (Kozhevnikov, 2007). In the context of mathematical literacy, which requires students to formulate, employ, and interpret mathematical concepts in real-world situations (OECD, 2023), these differences become highly consequential. The significant interaction found in this study suggests that the demands of the learning environment interact with these cognitive characteristics, resulting in differential learning outcomes.

The superior performance of FI students in the Problem-Based Learning setting can be explained through several interrelated mechanisms. First, PBL inherently involves ill-structured problems that require students to independently analyze situations, extract relevant information, and construct solution strategies. These processes align closely with the analytical and disembedding abilities of FI learners, enabling them to navigate complex problem contexts more effectively (Kozhevnikov, 2007). Second, PBL emphasizes self-directed and self-regulated learning, where students are expected to plan, monitor, and evaluate their own learning processes. FI students, who are generally more autonomous and less dependent on external guidance, are better equipped to manage these demands (Zimmerman, 2020). As a result, they are more capable of engaging deeply with problem-solving tasks, which in turn enhances their mathematical literacy skills.

In contrast, FD students tend to benefit more from structured and guided learning environments. Their reliance on external cues and social interaction means that they may experience difficulties when confronted with the open-ended and less structured nature of PBL. This does not imply that PBL is ineffective for FD learners; rather, it suggests that the implementation of PBL should be accompanied by appropriate scaffolding strategies, such as guided questioning, structured worksheets, and collaborative support. Evidence indicates that FD learners can achieve comparable performance to FI learners when instructional materials are well-organized and support cognitive processing effectively (Shipstead & Broadway, 2013)

Furthermore, the interaction effect observed in this study underscores the importance of instructional alignment in mathematics education. Mathematical literacy is not merely a function of content mastery but also involves higher-order thinking skills, including reasoning, problem-solving, and contextual interpretation (OECD, 2023). PBL, with its emphasis on contextual and inquiry-based learning, provides a suitable environment for developing these competencies, particularly for learners who possess strong analytical tendencies. This finding is consistent with prior research demonstrating that problem-based and inquiry-oriented approaches foster higher-order thinking and meaningful learning (Hmelo-Silver, 2004).

These findings have important pedagogical implications. Teachers should not assume that a single instructional model will be equally effective for all students. Instead, they need to consider students' cognitive diversity when designing and implementing learning activities. For instance, while PBL may be highly effective for FI students, its effectiveness for FD students can be enhanced through structured guidance and collaborative learning opportunities. Therefore, a differentiated instructional approach that integrates both student-centered and teacher-guided elements is essential for optimizing learning outcomes.

CONCLUSION

This study confirms a significant interaction between learning models and cognitive styles in influencing students' mathematical literacy abilities. Students with a field-independent cognitive style taught using Problem-Based Learning achieved the highest levels of mathematical literacy, indicating that the effectiveness of PBL depends on students' cognitive characteristics. This finding reinforces the view that mathematical literacy development is determined not only by the learning model but also by how students process, organize, and apply information during learning. These results imply that implementing PBL in mathematics classes should not be treated as a one-size-fits-all approach for all students. Instead, teachers need to adopt more adaptive learning designs that consider students' cognitive styles. A PBL environment, which emphasizes open-ended problem-solving and independent inquiry, is particularly beneficial for students with a field-independent cognitive style due to their analytical and autonomous learning tendencies. However, for students with a field-dependent cognitive style, the effectiveness of PBL can be enhanced through structured support, guided instruction, and collaborative learning support. Therefore, integrating strategies that consider cognitive styles in PBL is crucial to ensure that all students can optimally benefit from the learning process. This study extends previous research by explicitly positioning cognitive style as a moderating variable shaping the effectiveness of PBL, thus offering a more nuanced understanding of how higher-order mathematical competencies are developed. Practically, this research offers actionable insights for educators, particularly in designing differentiated mathematics instruction that aligns pedagogical strategies with students' cognitive profiles to improve learning outcomes. Despite these contributions, this study is limited to a sample of junior high school students and primarily focuses on cognitive variables. Future research is recommended to test the robustness of these findings across different educational settings, grade levels, and cultural contexts. Furthermore, further studies should incorporate affective variables such as self-efficacy, motivation, or math anxiety to provide a more comprehensive understanding of the factors influencing mathematical literacy. Such investigations would be invaluable in developing more holistic and inclusive learning models in mathematics education.

REFERENCES

Alghofiqi, R., Solihatin, E., & Yufiarti. (2020). Pengaruh kemandirian belajar dan gaya kognitif terhadap hasil belajar ips siswa kelas vii smp negeri singkawang. *JPD: Jurnal Pendidikan Dasar*, 95–103. https://doi.org/10.21009/JPD.012.02

Ali, S. S. (2019). Problem based learning: A student-centered approach. *English Language Teaching*, 12(5), 73. https://doi.org/10.5539/elt.v12n5p73

Amini, A., Nufus, H., & Agustin, E. (2023). Identifikasi kemampuan berpikir kreatif siswa dari sudut pandang gaya kognitif dalam pembelajaran matematika. *Juring (Journal for Research in Mathematics Learning)*, 6(3), 285. https://doi.org/10.24014/juring.v6i3.25627

Eka, I. W., Sadia, I. W., & Suastra, I. W. (2014). Pengaruh model pembelajaran perubahan konseptual terhadap pemahaman konsep siswa ditinjau dari gaya kognitif. *Journal Program Pascasarjana Universitas Pendidikan Ganesha Program Studi IPA*, 4.

Farmaki, C., Sakkalis, V., Loesche, F., & Nisiforou, E. A. (2019). Assessing field dependence–independence cognitive abilities through eeg-based bistable perception processing. *Frontiers in Human Neuroscience*, 13. https://doi.org/10.3389/fnhum.2019.00345

Ginting, S. D., & Nasution, H. A. (2024). Analisis kesulitan siswa ditinjau dari gaya kognitif field independent dan field dependent. *Jurnal Cendekia : Jurnal Pendidikan Matematika*, 8(1), 305–315. https://doi.org/10.31004/cendekia.v8i1.3063

Gufron, A., Hidayah, I., Prabowo, A., Wardono, & Mariani, S. (2025). The effectiveness of problem-based learning in enhancing mathematical literacy: A systematic meta-analysis. *Jurnal Elemen*, 11(2), 483–501. https://doi.org/10.29408/jel.v11i2.30002

Habeahan, W. L., Malik, M., Firdaus, M. H., & Panjaitan, A. C. (2025). The influence of cognitive style on abstraction ability and mathematical problem-solving in problem-based learning. *Alacrity : Journal of Education*, 554–561. https://doi.org/10.52121/alacrity.v5i1.677

Haryadi, R., Situmorang, R., & Khaerudin. (2021). Effectiveness of use direct learning models for higher order thinking skills of pre-service physics teachers. *Journal of Physics: Conference Series*, 1806(1), 012042. https://doi.org/10.1088/1742-6596/1806/1/012042

Hendroanto, A., Istiandaru, A., Syakrina, N., Setyawan, F., Prahmana, R. C. I., & Hidayat, A. S. E. (2018). How students solves pisa tasks: an overview of students' mathematical literacy. *International Journal on Emerging Mathematics Education*, 2(2), 129. https://doi.org/10.12928/ijeme.v2i2.10713

Hmelo-Silver, C. E. (2004). Problem-based learning: what and how do students learn?. *Educational Psychology Review*, 16(3), 235–266. https://doi.org/1040-726X/04/0900-0235/0

Huda, N., & Khotimah, N. (2023). Model pembelajaran problem based learning (pbl) untuk meningkatkan litersi matematika siswa. *Mathema Journal*, 5(2), 299–311

Ikhlas, A. (2018). Pengaruh model pembelajaran berbasis masalah dan gaya kognitif siswa terhadap hasil belajar matematika siswa di kelas viii smp negeri 7 kerinci. *Jurnal Ilmiah Ilmu Terapan Universitas Jambi*, 2(2), 135–143. https://doi.org/https://doi.org/10.22437/jiituj.v2i2.5988

Izzati, M., Muchlis, E. E., Susanto, E., Patri, S. F. D., Kristiani, F., & Stanggo, P. D. (2025). The influence of student worksheets based on pbl-mathematical literacy on problem-solving in junior high schools in bengkulu. *International Journal of Mathematics and Mathematics Education*, 3(2), 144–122. https://doi.org/10.56855/ijmme.v3i2.1374

Janah, S. R., Suyitno, H., & Rosyida, I. (2019). Pentingnya literasi matematika dan berpikir kritis matematis dalam menghadapi abad ke-21. *PRISMA, Prosiding Seminar Nasional Matematika*, 2, 905–910. https://journal.unnes.ac.id/sju/index.php/prisma/

Junaidi, M. (2018). Model pembelajaran langsung (direct instruction) (pengajaran aktif (good & grows)); cbsa (cara belajar siswa aktif), mastery teaching (hunter), dan explicit instruction (rosenshine & stevens). *Jurnal Pendidikan Islam*, 42–55.

Kozhevnikov, M. (2007). Cognitive styles in the context of modern psychology: toward an integrated framework of cognitive style. *Psychological Bulletin*, 133(3), 464–481. https://doi.org/10.1037/0033-2909.133.3.464

Mansur, N. (2018). Melatih literasi matematika siswa dengan soal pisa. *Prisma, Prosiding Seminar Nasional Matematika*, 140–144. https://journal.unnes.ac.id/sju/index.php/prisma/

Salam, M., Ndia, L., Misu, L., Jafar, J., Suhar, S., & Hasnawati, H. (2024). Applying scaffolding technique in problem based learning (pbl) model on students' mathematics problem solving ability. *World Journal of Advanced Research and Reviews*, 21(3), 1372–1379. https://doi.org/10.30574/wjarr.2024.21.3.0846

Mumu, J., Prahmana, R. C. I., Tanujaya, B., & Sampouw, F. (2025). In-service teachers' perceptions of problems in mathematics instruction when using a problem-based learning model. *Journal on Mathematics Education*, 16(4), 1463–1482. https://doi.org/10.22342/jme.v16i4.pp1463-1482

Muslimah, H., & Pujiastuti, H. (2021). Analisis kemampuan literasi matematis siswa dalam memecahkan masalah matematika berbentuk soal cerita. *Jurnal Pendidikan Matematika Dan Sains*, 8(1), 36–43. https://doi.org/10.21831/jpms.v8i1.30000

Muzaki, A., & Masjudin, D. (2019). Analisis kemampuan literasi matematis siswa. *Mosharafa: Jurnal Pendidikan Matematika*, 8(3), 493–502. https://doi.org/10.31980/mosharafa.v8i3.557

Nicholus, G., Muwonge, C. M., & Joseph, N. (2023). The role of problem-based learning approach in teaching and learning physics: A systematic literature review. *F1000Research*, 12, 951. https://doi.org/10.12688/f1000research.136339.2

Nurfitriani, Y., Yusuf, Y., Koswara, U., & Negeri, S. (2024). Mathematical literacy ability of students from a cognitive style perspective on rational numbers. *Edumatsains: Jurnal Pendidikan Matematika Dan Sains*, 9(1), 319–331. https://doi.org/10.33541/edumatsains

Nurlaela, E., & Imami, A. I. (2022). Peningkatan kemampuan literasi matematika siswa melalui penerapan model pembelajaran problem based learning di kelas vii smpit insan harapan. *Jurnal Ilmiah Dikdaya*, 12(1), 33. https://doi.org/10.33087/dikdaya.v12i1.270

OECD. (2010). *Mathematics framework In pisa 2009 assesment framework: key competencies in reading, mathematics and science* (pp. 83–123). OECD Publishing.

OECD. (2013). *PISA 2012 assessment and analytical framework : mathematics, reading, science, problem solving and financial literacy*. OECD.

OECD. (2019). *How did countries perform in pisa 2018?* I (PISA 2018 Result). OECD PUBLISHING. https://doi.org/10.1787/888934028235

OECD. (2023). *PISA 2022 assessment and analytical framework*. OECD. https://doi.org/10.1787/dfe0bf9c-en

Pimdee, P., Sukkamart, A., Nantha, C., Kantathanawat, T., & Leekitchwatana, P. (2024). Enhancing thai student-teacher problem-solving skills and academic achievement through a blended problem-based learning approach in online flipped classrooms. *Heliyon*, 10(7), e29172. https://doi.org/10.1016/j.heliyon.2024.e29172

Prihatiningtyas, N. C., & Buyung, B. (2023). Kemampuan literasi matematis siswa melalui implementasi model problem based learning berbasis etnomatematika pada budaya tidayu. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, 12(1), 215. https://doi.org/10.24127/ajpm.v12i1.5297

Purnama, M. I., Fisher, D., Subaryi, & Anggiana, A. D. (2023). Kemampuan literasi matematis siswa smp melalui model problem-based learning dengan teknik murder. Symmetry | *Pasundan Journal of Research in Mathematics Learning and Education,* 8(1), 146–157. https://doi.org/10.23969/symmetry.v8i1.8252

Rahayu, D. U., Mulyono, M., & Cahyono, A. N. (2021). Mathematical literacy reviewed from the student's cognitive style in the problem based learning learning model assisted by the learning management system. *Unnes Journal of Mathematics Education Research*, 10(2), 171–179. http://journal.unnes.ac.id/sju/index.php/ujmer

Retnawati, S., Charitas, R., Prahmana, I., & Arnal-Palacián, M. (2024). The impactful developed PISA-type problems for students' mathematical literacy through the context of Siger tower. *Pasundan Journal of Mathematics Education*, 14(1), 1–16. https://doi.org/10.23969/pjme.v14i1.15556

Setiawan, A., Degeng, I. N. S., Sa'dijah, C., & Praherdhiono, H. (2020). The effect of collaborative problem solving strategies and cognitive style on students' problem solving abilities. *Journal for the Education of Gifted Young Scientists*, 8(4), 1618–1630. https://doi.org/10.17478/jegys.812781

Setyaningsih, R., & Munawaroh, L. (2022). Analisis kemampuan literasi matematis siswa dalam menyelesaikan soal berorientasi pisa konten uncertainty and data. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, 11(3), 1656. https://doi.org/10.24127/ajpm.v11i3.4948

Shiddieqy, M. Z. A., Sudiana, R., & Pamungkas, A. S. (2023). Analisis kemampuan koneksi matematis ditinjau dari gaya kognitif siswa field dependent dalam menyelesaikan soal literasi numerasi kata kunci. *JIIP (Jurnal Ilmiah Ilmu Pendidikan)*, 6(9). https://doi.org/https://doi.org/10.54371/jiip.v6i9.2799

Shipstead, Z., & Broadway, J. M. (2013). Individual differences in working memory capacity and the Stroop effect: Do high spans block the words? *Learning and Individual Differences*, 26, 191–195. https://doi.org/10.1016/j.lindif.2012.04.003

Subaryo. (2022). Analisis kemampuan literasi matematis melalui model pembelajaran berbasis masalah pada siswa sekolah menengah. *Symmetry: Pasundan Journal of Research in Mathematics Learning and Education*, 7, 128–134. https://doi.org/10.23969/symmetry.v7i2.7047

Suhaji, I. P., Widadah, S., & Sukriyah, D. (2020). Kemampuan berpikir reflektif dalam memecahkan masalah matematika ditinjau dari gaya kognitif. *Zeta - Math Journal*, 5(1), 8–15. https://doi.org/10.31102/zeta.2020.5.1.8-15

Surur, M., Degeng, I. N. S., Setyosari, P., & Kuswandi, D. (2020). The effect of problem-based learning strategies and cognitive styles on junior high school students' problem-solving abilities. *International Journal of Instruction*, 13(4), 35–48. https://doi.org/10.29333/iji.2020.1343a

Suyuti, Ningsih, S. Y., Safar, M., Purhanudin, MS. V., & Shofiah, S. (2023). Pengaruh model pembelajaran inquiry dan gaya kognitif field independent (fi) & field dependent (fd) terhadap hasil belajar siswa. *Journal on Education*, 06(01), 293–306.

Wijaya, A. P. (2016). Gaya kognitif field dependent dan tingkat pemahaman konsep matematis antara pembelajaran langsung dan stad. *Derivat*, 3(2), 1–16. https://doi.org/https://doi.org/10.31316/j.derivat.v3i2.713

Wulan, E. R., & Anggraini, R. E. (2019). Gaya kognitif field-dependent dan field-independent sebagai jendela profil pemecahan masalah polya dari siswa smp. *Factor M: Focus Action Of Research Mathematics*, 1(2). https://doi.org/10.30762/f_m.v1i2.1503

Yani, I., Budiana, S., Rostikawati, T., Sundari, F. S., & Umam, M. A. K. (2025). Enhancing students' pollution problem-solving skills through problem-based learning: the moderating role of mathematical literacy. *Journal of Mathematics Instruction, Social Research and Opinion*, 4(2), 347–356. https://doi.org/10.58421/misro.v4i2.431

Yusuf, Y., & Sukestiyarno, YL. (2022). Pre-service teachers' statistical reasoning based on cognitive style. *Jurnal Didaktik Matematika*, 9(1), 136–150. https://doi.org/10.24815/jdm.v9i1.24538

Zhang, L., & Sternberg, R. J. (2005). A threefold model of intellectual styles. *Educational Psychology Review*, 17(1), 1–53. https://doi.org/10.1007/s10648-005-1635-4

Zimmerman, B. J. (2020). Self-regulated learning and academic achievement. *Educational Psychology Review*, 32, 321–335