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THE IMPACT OF PROBLEM-BASED LEARNING ON REDUCING SCIENCE MISCONCEPTIONS AND ENHANCING SCIENTIFIC LITERACY: INTEGRATING BALINESE LOCAL WISDOM AND COGNITIVE STYLE

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ABSTRACT

This study examined the effects of a Problem-Based Learning (PBL) model oriented to Balinese local wisdom and students' cognitive styles on misconceptions and scientific literacy. A quasi-experimental design with a 3×2 factorial arrangement was employed, involving three learning models (PBL with local wisdom, standard PBL, and conventional learning) and two cognitive styles (reflective vs. impulsive). The sample consisted of 178 fifth-grade students from 12 schools, selected through a multi-stage random sampling process. Data were collected using a misconception test ($\alpha = 0.92$), a scientific literacy test ($\alpha = 0.79$), and the Matching Familiar Figures Test ($\alpha = 0.72$). Results of two-way MANOVA showed significant main effects of learning model (Wilks' $\Lambda = 0.697$, $F = 16.93$, $p < 0.001$), and cognitive style (Wilks' $\Lambda = 0.407$, $F = 124.7$, $p < 0.001$). A significant interaction was also observed between learning model and cognitive style (Wilks' $\Lambda = 0.859$, $F = 6.73$, $p < 0.001$). Reflective students benefited most from PBL with Balinese local wisdom, showing the lowest misconceptions and highest scientific literacy, while impulsive students performed relatively better under conventional learning. These findings emphasize the importance of integrating cultural context and cognitive diversity into science education.

Keywords: problem-based learning; Balinese local wisdom; cognitive styles; misconceptions; scientific literacy

INTRODUCTION

Scientific literacy enables young people to make responsible decisions on issues such as climate change, health, and natural resource use. However, Indonesia still faces major challenges, as shown by PISA results indicating low levels of scientific literacy. One root problem is the persistence of misconceptions (students' understandings that contradict accepted scientific concepts), which hinder critical thinking and knowledge application (Vosniadou, 2019; Chen et al., 2020; Astawan et al., 2023). Misconceptions are closely related to science learning difficulties (Suliyanah et al., 2018; Chen et al., 2020b) and, if unaddressed, they obstruct accurate decision-making (Vosniadou & Skopeliti, 2014; Martawijaya et al., 2023). Misconceptions may persist due to errors in teaching (Desstya et al., 2019; Suprapto, 2020) or mismatches between prior knowledge and formal theory (Masfuah & Fakhriyah, 2021; Hayati et al., 2022).

Elementary science in Indonesia often emphasizes observation and experimentation

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(Saputri et al., 2016; Maknun, 2020). However, classroom practice remains conventional, with limited integration of students' cultural context. In Bali, preliminary data showed that more than 60% of fifth-grade students held misconceptions about energy and ecosystems, and teachers rarely incorporated Balinese local wisdom systematically, despite its rich ecological values and scientific relevance (Suliyanah et al., 2018; Astawan et al., 2019). Prior studies confirm that integrating local wisdom can enhance scientific literacy (Saefullah et al., 2017; Indrawan & Mahendra, 2021; Sanjayanti et al., 2022; Norazilawati, 2023; Rahmaveira & Ardianti, 2024).

Problem-Based Learning (PBL) has also been proven effective in fostering critical thinking, reducing misconceptions, and improving conceptual understanding by engaging students in real-life problem solving (Nafiah & Suyanto, 2014; Pei, 2019; Harahap et al., 2019; Aryawati, 2020a; Rusmansyah et al., 2023). Research shows that PBL enhances active, systematic learning and collaborative problem solving (Sepriyani et al., 2018; Maryati, 2018; Fıtrıanı et al., 2020; Hidayati & Wagiran, 2020; Sari & Prasetyo, 2021; Herlina & Kelana, 2021; Ikstanti & Yulianti, 2023; Fauziah et al., 2024).

At the same time, learning outcomes depend on students' cognitive styles. Reflective learners tend to respond carefully and accurately, while impulsive students answer quickly but less precisely (Al-Salameh, 2011; Armstrong et al., 2012; Sellah et al., 2017; Jelatu et al., 2019; Margunayasa et al., 2019; Fadillah et al., 2019; Aryawati, 2020; Muttaqin, 2020; Surur et al., 2020; Kalmatova et al., 2024). This highlights the need to align pedagogy with the characteristics of students.

Although previous studies have shown the benefits of PBL and local wisdom separately (Saefullah et al., 2017; Harahap et al., 2019; Rusmansyah et al., 2023; Norazilawati, 2023), little is known about their interaction with students' cognitive styles. Since cognitive style influences how students process information and solve problems (Kalmatova et al., 2024), one model may not be equally effective for all students. This study, therefore, investigates the effects of a PBL model oriented to Balinese local wisdom and cognitive style (reflective vs. impulsive) on misconceptions and scientific literacy among elementary students.

The expected outcome of this study is to provide empirical evidence that integrating PBL with Balinese local wisdom can effectively reduce misconceptions and enhance students' scientific literacy, particularly for those with a reflective cognitive style. At the same time, the study is expected to highlight the limitations of conventional approaches for fostering deep conceptual understanding, while offering practical insights into how instructional design can be differentiated to accommodate diverse cognitive styles. Beyond its theoretical contribution, the research aims to inform teachers, curriculum developers, and policymakers about the value of incorporating cultural contexts and student characteristics into science instruction, ultimately supporting the achievement of SDG 4 on Quality Education in Indonesia.

METHODS

The research employed a quasi-experimental design with a 3 × 2 factorial structure (Creswell & Creswell, 2018). The study involved two independent variables — learning models and cognitive styles — and two dependent variables: student misconceptions and scientific literacy. The first independent variable was the learning model, which included three types: (1) a problem-based learning (PBL) model oriented to Balinese local wisdom, (2) a standard problem-based learning model without a local wisdom orientation, and (3) a conventional learning model. The PBL model, grounded in Balinese local wisdom, incorporates traditional Balinese values and cultural elements into each step of the PBL process. The syntax consists of: (a) orienting students to the problem, (b) organizing students for learning, (c) guiding individual and group investigations, (d) developing and presenting work, and (e) analyzing and evaluating the problem-solving process.

The second independent variable was students' cognitive style, categorized as either reflective or impulsive. Reflective cognitive style refers to a student's tendency to respond slowly but accurately, while impulsive cognitive style indicates a tendency to respond quickly but inaccurately. The dependent variables were student misconceptions, defined as scientifically inaccurate understandings, and scientific literacy, which refers to the ability to apply scientific knowledge to solve daily problems.

The study population consisted of fifth-grade students from 43 public elementary schools in Singaraja City, Bali, divided into nine clusters. The sample was selected using a multi-stage random sampling method. This multi-stage random approach was chosen to reduce selection bias, achieve proportional representation across school clusters, and increase the generalizability of findings across the city context. In the first stage, 40% of the clusters were randomly selected: Clusters II, III, IV, and VII. In the second stage, three schools were randomly chosen from each selected cluster, resulting in a total of 12 schools. In the third stage, the 12 schools were randomly assigned to three groups: four schools formed Experimental Group 1 (E1), which implemented the PBL model based on Balinese local wisdom (SDN 1 Penarukan, SDN 3 Penarukan, SDN 2 Banyuning, and SDN 6 Banyuning; n = 60); four schools formed Experimental Group 2 (E2), which applied the standard PBL model (SDN 1 Astina, SDN 1 Paket Agung, SDN 2 Penarukan, and SDN 1 Tukadmungga; n = 58); and the remaining four schools served as the control group using conventional learning methods (SDN 1 Banjar Jawa, SDN 5 Penarukan, SDN 1 Banyuning, and SDN 1 Pemaron; n = 60).

The research procedure included three main stages. First, students' cognitive styles were identified using the Matching Familiar Figures Test (MFFT). Second, the respective learning models were implemented in each group over the course of seven sessions covering the topics of energy sources, heat, and heat transfer. Finally, students completed post-tests to assess their level of misconception and scientific literacy.

Research ethics were strictly observed. Prior to data collection, approval was obtained from the Research Ethics Committee of Universitas Pendidikan Ganesha, as well as formal permission from the Singaraja Education Office and the participating schools. Written informed consent was secured from parents/guardians, while students were informed of the voluntary nature of their participation. Anonymity and confidentiality were maintained throughout the study, and the data were used solely for research purposes.

Data were collected using three instruments: a misconception test, a scientific literacy test, and the MFFT. The misconception test consisted of multiple-choice items designed using the Certainty of Response Index (CRI) technique, with a reliability coefficient of 0.92. The CRI used a 6-point Likert scale (0–5) to assess students' confidence in their answers. A student was identified as having a misconception if they answered incorrectly with a high confidence level (CRI > 2.5). The scientific literacy test comprised 30 multiple-choice items (reliability = 0.79), covering three indicators: (1) evaluating the use and misuse of scientific information, (2) solving problems using quantitative reasoning (including probability and statistics), and (3) justifying inferences, predictions, and conclusions based on quantitative data. The MFFT consisted of 13 items (reliability = 0.72) and was used to determine students' cognitive style. Students were categorized as reflective if they answered at least seven questions correctly and spent at least 7.5 minutes on the task. Conversely, students were classified as impulsive if they answered at least seven questions incorrectly and spent <7.5 minutes. The instrument summary is shown in Table 1.

Table 1. Instrument Summary

Instrument	Number of Items	Validation Method	CVI	Reliability (α)
Misconception Test	25	Expert Judgment + Pilot	0.92	0.92
Scientific Literacy Test	30	Expert Judgment + Pilot	0.88	0.79
MFFT (Cognitive Style Test)	13	Adapted + Pilot Study	–	0.72

Data analysis was conducted using two-way Multivariate Analysis of Variance (MANOVA) to examine the effects and interactions between learning models and cognitive styles on students' misconceptions and scientific literacy. The statistical analysis was performed using SPSS version 25.0.

RESULTS AND DISCUSSION

The research data were analyzed to test the hypothesis regarding the effect of the problem-based learning model, oriented to Balinese local wisdom and cognitive style, on students' misconceptions and scientific literacy. The descriptive statistics, including the mean scores and standard deviations for each group, are presented to provide an overview of the outcomes obtained. The primary analysis utilized a two-way multivariate analysis of variance (MANOVA) to test the research hypothesis. The results of the data analysis on misconceptions and scientific literacy, based on learning models and cognitive styles, are presented in Table 2.

Table 2. Student Misconceptions (SM) and Scientific Literacy (SL)

Learning Models (A) / Cognitive Styles (B)	Problem-based Learning Model with Balinese Local Wisdom (A1)	Problem-based Learning Model (A2)	Conventional Learning Model (A3)	Overall
Reflective (B1)	SM = 4.55 SL = 24.28	SM = 6.61 SL = 22.14	SM = 7.28 SL = 21.52	SM = 6.14 SL = 22.65
Impulsive (B2)	SM = 7.19 SL = 19.19	SM = 8.50 SL = 17.40	SM = 8.16 SL = 19.29	SM = 7.95 SL = 18.64
Overall	SM = 5.92 SL = 21.65	SM = 7.59 SL = 19.69	SM = 7.73 SL = 20.37	

Based on Table 2, three hypotheses were tested: 1) there is an influence of a problem-based learning model oriented towards Balinese local wisdom on misconceptions and scientific literacy, 2) there is an influence of cognitive style on misconception and scientific literacy, and 3) there is an influence of the interaction of problem-based learning with Balinese local wisdom and cognitive styles on misconception and scientific literacy.

Based on the results of the statistical analysis conducted, the research findings suggest that the cognitive style of fifth-grade students influences the misconceptions they encounter. It was found that students with a reflective cognitive style experienced lower misconceptions than students with an impulsive cognitive style. Students with a reflective cognitive style in the learning process and when answering questions tend to be careful and considerate, allowing them to understand concepts well and avoid misconceptions. In contrast, students with an impulsive cognitive style tend to be fast but often in a hurry. Hence, they are less than optimal in understanding concepts, which can lead to misconceptions (Aini & Wiryanto, 2020). This is because cognitive style is a person's characteristic in receiving, analyzing, and responding to given cognitive actions (Armstrong et al., 2012). According to the tempo or speed of thinking, cognitive styles can be divided into two main categories: reflective cognitive style and impulsive cognitive style. Students with a reflective cognitive style tend to respond more slowly to problems because they require a relatively long time to think about the issues presented. Hence, the answers to problems tend to be correct and appropriate (Margunayasa et al., 2019). Meanwhile, students with an impulsive cognitive style tend to respond quickly to problems without engaging in deep reflection, which can result in incorrect answers. Cognitive style refers to the characteristics of each individual in information processing, decision-making, and learning efficiency, based on extraversion-introversion and thinking-feeling patterns, which influence how individuals interact in the learning process (Kalmatova et al., 2024; Susiloningsih et al., 2024).

Different students' cognitive styles result in varying concepts being received by each student during the learning process (Margunayasa et al., 2019). The acceptance of incorrect concepts by students leads to misconceptions or conceptual errors (Schmidt, 1997; Sisman & Aksu, 2016). If misconceptions occur among students and are left unaddressed, they can contribute to a lack of understanding of key concepts, and students will be less able to answer questions correctly (Rahmawati et al., 2022). Analytical thinkers tend to engage in detailed analysis, leading to better performance in structured tasks, whereas realistic thinkers may excel in practical applications but require different instructional approaches (Разумникова, 2024). In contrast, the finding that the conventional model better accommodated impulsive students is important. This finding should not be interpreted as an endorsement of conventional teaching, but rather as an indication of a cognitive mismatch between impulsive students and the demands of the unstructured PBL environment. Impulsive students tend to seek quick solutions and are prone to making errors due to inadequate analysis (Garg et al., 2022). The high intrinsic cognitive load of the complex and unstructured problems in the PBL process may have overloaded their processing capacity, leading to shallow engagement and poorer outcomes. The more structured and teacher-centered nature of the conventional model, although less effective for deep learning, may have provided the necessary scaffolding and reduced cognitive load for these students, allowing them to reach a basic level of understanding (Kirschner, 2019).

Before testing the hypothesis, prerequisite tests are first carried out, including normality testing and homogeneity testing. Normality testing was carried out using the Kolmogorov–Smirnov test. Meanwhile, homogeneity testing was carried out using the Box test. The analysis results for all groups of misconceptions and scientific literacy data yielded a significance level of more than 0.05, indicating that all groups of misconceptions and scientific literacy data in this study originated from a normally distributed population. The significance value of the Box test results is 0.130, which is greater than 0.05, indicating that the data on misconceptions and scientific literacy have homogeneous variance. Since the prerequisite testing has been fulfilled, the results of the hypothesis testing are presented in Table 3.

Table 3. Hypothesis Testing Results

Effect		Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	.994	1.461	2.000	171.000	.000
	Wilks' Lambda	.006	1.461	2.000	171.000	.000
	Hotelling's Trace	170.867	1.461	2.000	171.000	.000
	Roy's Largest Root	170.867	1.461	2.000	171.000	.000
Learning Model	Pillai's Trace	.309	15.729	4.000	344.000	.000
	Wilks' Lambda	.697	16.926	4.000	342.000	.000
	Hotelling's Trace	.426	18.124	4.000	340.000	.000
	Roy's Largest Root	.405	34.835	2.000	172.000	.000
Cognitive Style	Pillai's Trace	.593	1.247	2.000	171.000	.000
	Wilks' Lambda	.407	1.247	2.000	171.000	.000
	Hotelling's Trace	1.459	1.247	2.000	171.000	.000
	Roy's Largest Root	1.459	1.247	2.000	171.000	.000
Model * Cognitive Style	Pillai's Trace	.141	6.530	4.000	344.000	.000
	Wilks' Lambda	.859	6.728	4.000	342.000	.000
	Hotelling's Trace	.163	6.923	4.000	340.000	.000
	Roy's Largest Root	.159	13.646	2.000	172.000	.000

Table 3 reveals several significant findings that 1) there are significant differences in students' misconceptions and scientific literacy among those who studied with the Balinese local wisdom problem-based learning model (PBL BLW), the standard problem-based learning model (PBL), and conventional learning (KV) ($p < 0.05$). 2) Significant differences also exist in students' misconceptions and scientific literacy between students with reflective (CS R) and impulsive (CS I) cognitive styles ($p < 0.05$). 3) A significant relationship is observed between the Balinese local wisdom problem-based learning model and students' cognitive styles concerning students' misconceptions and scientific literacy ($p < 0.05$).

The results of research conducted using statistical tests indicate an influence of the problem-based learning model on misconceptions in grade 5 elementary schools in Singaraja City. The problem-based learning model in this learning process presents real-world problems that differ from students' everyday understanding, thereby enhancing their in-depth understanding and improving their high-level thinking and problem-solving skills (Savery, 2015). This problem-based learning model can help students become accustomed to compiling their knowledge independently and can foster students' self-confidence in solving problems (Yew & Goh, 2016). Problem-based learning (PBL) utilizes problems from students' daily lives in the learning process to motivate them to learn. In implementing problem-based learning, the teacher organizes student learning activities that involve working in groups to solve problems presented by the teacher, which are related to daily life and the learning material. Students can gradually solve problems through the steps of the problem-based learning model (Nurtanto et al., 2018; Yew & Goh, 2016). In its application, the problem-based learning model consists of five steps: (1) directing students to the problem, (2) organizing learning activities, (3) guiding independent and group investigations, (4) developing and presenting the results of the work, and (5) carrying out analysis and evaluation of the problem solving process (Nasution et al., 2018).

The steps in the problem-based learning model are well-structured and provide an opportunity for students to develop their problem-solving abilities, thereby understanding the concepts presented in the learning material. The problem-based learning model has the characteristics of enabling students to think critically, collaborate in teams in both social and knowledge interactions, and engage in active problem-solving with data analysis skills (Saputra et al., 2019). The characteristics of the problem-based learning model include: (1) problems are used as a stimulus and focus of student learning activities, (2) problems raised in learning are usually cases related to the learning material being studied which is connected to students' daily lives, (3) students can resolve the problems raised in the learning focus through discussions with groups which are expected to produce various learning experiences including learning experiences related to problem solving and collaboration in groups (Sockalingam & Schmidt, 2011). The problem-based learning model looks successful if students understand the learning concepts (Yew & Goh, 2016). In the implementation of learning in elementary schools before the implementation of the problem-based learning model, students tended to participate passively in the learning process, so that understanding of concepts in the learning material was not conveyed well, causing students to understand the wrong concepts in the learning material, or what is often called a misconception (Saputri et al., 2016). Misconceptions can persist even if students are exposed to them. There are concrete examples of heat experiments and their transfer in everyday life. However, after entering the problem-solving stage, students were immediately asked questions about heat and its transfer, causing them to struggle with understanding this concept.

Meanwhile, in the learning process using the problem-based learning model, students are given problems related to daily life to discuss with the group (Ekaningsih, 2021). The questions are then discussed with the group, making the initially abstract questions more structured and allowing the concepts in the learning material to be understood more clearly (Simbolon & Koeswanti, 2020). The problem-based learning model encourages students to be more active in the learning process by conducting experiments and engaging in discussions, facilitating student interaction in answering questions that clarify incorrect conceptions and establish correct concepts (Anggreni et al., 2023).

The interaction between the problem-based learning model and Balinese local wisdom, as well as cognitive style, on students' misconceptions and scientific literacy, is also illustrated in Figures 1 and 2.

Figure 1. Interaction between the Balinese Local Wisdom Problem-Based Learning Model and Cognitive Style Against Misconceptions

Based on research conducted, it is known that the problem-based learning model can be adapted differently by students with varying cognitive styles. Students with a reflective cognitive style tend to be slow and careful in solving problems; however, they solve problems well and correctly when concepts are understood and applied with the problem-based learning model (Maulana et al., 2020). Meanwhile, students with an impulsive cognitive style tend to be faster at solving the given problems. However, problem-solving tends to be slow, inappropriate, or not aligned with the correct concept in implementing the problem-based learning model (Fadiana, 2015). Accepting the different applications of the problem-based learning model among students with reflective and impulsive cognitive styles leads to a distinct understanding of concepts (Anggreni et al., 2023). Based on the results of the statistical analysis carried out, the significance value is 0.003 ($0.003 < 0.05$). This result suggests an interaction between the problem-based learning model and cognitive styles in terms of misconceptions. Cognitive style influences how students process information, abilities, and problem-solving skills (Margunayasa et al., 2019; Surur et al., 2020; Anggreni et al., 2023). Through the problem-based learning model, students are actively involved in improving their ability to solve problems, think critically, and organize their knowledge through the problem-solving process that has been implemented (Fadiana, 2015; Nurtanto et al., 2018).

The most important finding of this study is the significant interaction effect, which indicates that no single learning model is superior for all students. The effectiveness of the Balinese local wisdom-oriented PBL model is highly dependent on students' cognitive styles. The data clearly demonstrate a strong alignment between the PBL model and the reflective cognitive style, resulting in the lowest misconceptions and the highest scientific literacy. This can be explained through the lens of cognitive-pedagogical alignment. The syntax of PBL, which involves problem analysis, data collection, synthesis, and solution testing, demands systematic and in-depth information processing. This aligns perfectly with the innate tendencies of reflective students, who are characterized by their careful, methodical, and accurate approach to problem solving (Kozhevnikov et al., 2022). The problem-based learning model can reduce misconceptions by providing problems closely related to students' daily lives, particularly those related to heat and its transfer. These problems can affect developing students' problem-solving skills, hinder the building of new knowledge, and impede the understanding of concepts learned more effectively. Cognitive style reveals how students process the information provided, allowing students with different cognitive styles to succeed in learning, provided they have employed the appropriate strategies (Riding & Rayner, 2013). Based on the analysis results, the average misconception of students in the reflective group, who were taught using the problem-based learning model, was lower than that of students who were not taught using this model. This finding aligns with the average misconception of students in the impulsive group, who were taught using the problem-based learning model, which was lower than that of the control group, which was not taught using the problem-based learning model. However, students with a reflective cognitive style, whether taught or not taught using the problem-based learning model, have a lower average of misconceptions than students in the impulsive group.

Using the PBL model, combined with Balinese local wisdom through activities, presents problems related to Balinese culture in the classroom, making learning more engaging and enjoyable. Heat transfer can be a topic related to Balinese people's activities, including the preparation of roasted suckling pig. Students, in this case, analyze the problem of preventing the roller from feeling hot when rolling the pig. Students enthusiastically answer this problem with an initial understanding because they often see the suckling pig-making process during religious ceremonies. In this case, the teacher invites students to solve the problem, allowing them to find the solution by reading books, asking the teacher or friends, and conducting simple experiments to prove it.

Combining the PBL model and Balinese local wisdom creates a classroom atmosphere that fosters active learning, where students are encouraged to conduct investigations to solve the given problems, thereby increasing their understanding of learning concepts (Restiani et al., 2023). Implementing learning using the PBL model can prevent misconceptions that students experience by having them analyze problems, prove the problem, and draw conclusions, thereby deepening their understanding of the learning concept (Khoiriyah et al., 2015; Nurtanto et al., 2018). In problem-solving activities using the PBL model with Balinese local wisdom, students with a reflective cognitive style tend to answer problems more slowly but slightly incorrectly, as they spend more time considering the correct answers and concepts related to the problem, resulting in fewer incorrect answers (Maulana et al., 2020). Impulsive students tend to answer more quickly but make many mistakes because they want to solve the problem given in a hurry, so the answer is more likely to be wrong. When presented with a problem-based learning model incorporating Balinese local wisdom, impulsive students gradually become more careful and cautious, as they initially rush to find answers without considering the correctness of their responses (Fadiana, 2015).

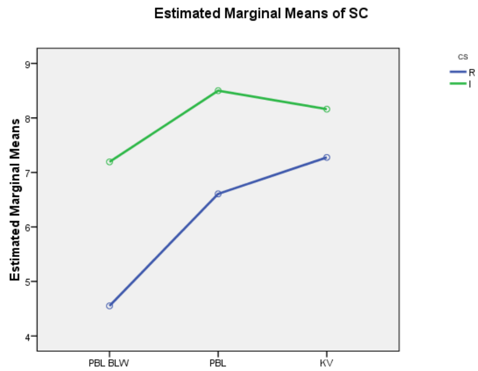

Figure 2. Interaction between the Balinese Local Wisdom Problem-Based Learning Model and Scientific Literacy Cognitive Style

The results of statistical testing indicate an influence of the problem-based learning model on scientific literacy among fifth-grade elementary school students in Singaraja City. This problem-based learning model is unique from other learning models because learning is triggered by problems closely related to students' daily lives, which students will later solve. The problem-based learning model has a typical learning arrangement triggered by problems that require solving (Yew & Goh, 2016). In its application in learning, the problem-based learning model often experiences common errors in its implementation (Wolk, 2022). These errors arise because learning conditions often overlook students' initial beliefs or understanding, as well as the differences in ideas held by students. Therefore, they need to be addressed through scientific methods to avoid these errors (Imbar & Winoto, 2024). The problem-based model is a learning approach where students acquire knowledge through active involvement in solving problems, thereby building their understanding. The PBL learning process emphasizes problem-solving, where students analyze given problems, solve them, and draw conclusions based on the results, thereby emphasizing scientific literacy (Nurtanto et al., 2018). Scientific literacy is essential in a learning process that emphasizes the mastery of concepts, analysis, problem-solving, critical thinking, and the application of knowledge obtained from learning (Rozi & Prawijaya, 2019).

This problem-based learning model consists of several stages in the learning process (Rozi & Prawijaya, 2019). At the student orientation stage, the teacher provides science learning problems connected to the surrounding environment. Students understand and analyze problems presented by teachers that require solutions. This problem-based learning model is triggered by a problem that exists in the lives of students, who will investigate the problem to find a solution provided (Samadun & Dwikoranto, 2022). At the stage of organizing students to learn, the teacher mobilizes students to form groups to discuss and solve the problems given (Amin et al., 2020). At the stage of guiding individual and group investigations, the teacher's role is to encourage students to collect appropriate information and conduct experiments to solve the problems (Ekaningsih, 2021). When students carry out an experimental process to solve problems, it provides them with valuable experience. It presents interesting opportunities for students during the investigation process, fostering the development of independent thinking, critical thinking, reasoning, and scientific perspectives (Kaneza et al., 2024). Here, students correct their misconceptions about their initial understanding of the problem presented by the teacher by testing it experimentally, thereby deepening their understanding of the science learning material (Parthasarathy, 2023). After solving the problem, students move to the stage of developing and presenting results. The teacher assists students in developing an appropriate report, and students then create and present it in front of the class (Parthasarathy, 2023). In the final stage, students analyze and evaluate the problem-solving process. The teacher's role is to help students reflect and evaluate the problem-solving process (Fıtrıanı et al., 2020).

This problem-based learning model invites students to solve problems related to real-life contexts related to science learning by carrying out practical activities to solve problems, so that they can provide a broader picture and experience related to scientific literacy, so that students will know and understand science better, and can apply it in solving the real problems they face. In problem-based learning, the teacher directs learning steps that accommodate literacy skills learning during student investigations to collect appropriate information to solve problems related to science learning material which is oriented towards a mutual question and answer (science) process between groups during experiments so that there is an exchange process information and based on appropriate sources and can distinguish whether a fact is a fact or not so that students can make decisions to solve problems (Ardianto & Rubini, 2016). This problem-based learning model also actively invites students to learn science, where students work together in groups to solve the problems given, so that students can solve problems gradually and can understand science, which has an impact on students' scientific literacy, which will form itself in the learning process (Nainggolan et al., 2021). This PBL learning model deepens students' understanding of science concepts because students gradually correct their misconceptions through experiments or investigations, as well as through the process of discussing and sharing results, which enhances their understanding of science concepts. The novelty of this study lies in the deviation of the results from claims that PBL is superior. While many studies confirm the benefits of PBL, they often ignore the moderating role of individual student characteristics. This study refines previous findings by showing that the superiority of PBL is not absolute; it depends on students' cognitive processing styles. By integrating three key variables —specific pedagogical model (PBL), cultural context (Balinese local wisdom), and cognitive traits (reflective/impulsive style) — this study provides a more detailed model for understanding student learning. This challenges the one-size-fits-all approach to educational innovation and empirically supports calls for differentiated instruction tailored to students' cognitive profiles (Tomlinson, 2017; Wilcox et al., 2020).

Based on the analysis, the problem-based learning model, incorporating Balinese local wisdom, influences students' scientific literacy. This is because the problem-based learning model, combined with Balinese local wisdom, is a learning approach that presents real-life problems to students in their daily lives (Yew & Goh, 2016). Learning that focuses on students' life problems will improve students' critical thinking skills, which are useful in the decision-making process regarding problem-solving solutions. This can also increase students' scientific literacy (Ardianto & Rubini, 2016).

Students have their own cognitive style in learning. Cognitive style is a person's unique way of processing or responding to various environmental situations (Margunayasa et al., 2019). Some students prefer to think more deeply about everything and observe, ask questions, and conduct thorough research before concluding, which is called reflective thinking. On the other hand, some students are more adept at acting quickly without overthinking. In contrast, these students prefer to carry out activities directly without overthinking, which is considered impulsive (Septiani & Purwanto, 2020). Scientific literacy is crucial for students' scientific abilities to identify and investigate knowledge, form scientific ways of thinking, and apply them in everyday life (Effendi et al., 2021).

Students with a reflective cognitive style will understand science differently from those with an impulsive cognitive style. Students with a reflective cognitive style will observe and ask questions before solving problems related to science learning so that they are not in a hurry to make decisions. Meanwhile, students with an impulsive cognitive style immediately experiment without asking and seeking data sources needed to carry out the experiments, as well as understanding the results of the experiments they have conducted. Students in the impulsive group tend to make decisions quickly, even though their accuracy is low, and often fail to reach a conclusion. The impulsive group tends to think reflectively regarding understanding and reflection, utilizing procedural strategies, whereas reflective students tend to think reflectively about the reflection and critical reflection stages, employing expert strategies (Salido et al., 2020).

Students with a reflective cognitive style tend to be more thorough and careful in solving problems to get the right results. In contrast, students with an impulsive cognitive style tend to make decisions quickly to solve problems, but are less careful, resulting in incorrect outcomes (Utami & Indriana, 2018). Students with an impulsive cognitive style tend to respond more quickly and make errors more frequently than those with a reflective cognitive style. However, they complete each trial more quickly by identifying the target.

Students with a reflective cognitive style tend to make slower decisions without making mistakes than those with an impulsive cognitive style because they are cautious and try to understand the problem more deeply. Students with a reflective cognitive style tend to be better at collaborating with their group friends than students with an impulsive cognitive style because students with a reflective cognitive style carefully make decisions about where they will exchange the information they have, and this is inversely proportional to students with an impulsive cognitive style who tend to do it directly and sometimes the results do not suit the group members. Students with a reflective cognitive style think more deeply, have a high level of curiosity to solve problems, and think creatively, which opens up opportunities for possible answers and provides new understanding to solve them. In contrast, students with an impulsive cognitive style have a higher level of curiosity. This can be associated with the solution and tends to solve problems, albeit minimally (Rahmatina et al., 2014).

The problem-based learning model triggers students to solve problems with careful consideration. Students with a reflective cognitive style tend to ask questions and seek sources before conducting experimental activities, and are not in a hurry to make decisions. On the other hand, students with an impulsive cognitive style tend to conduct experiments without consultation and often encounter problems. However, both types of students understand science through the problem-based learning model. The problem-based learning model allows students to actively apply their knowledge and skills to find solutions to the given problems, enabling them to solve the problems effectively. Students with a reflective cognitive style tend to process problems more carefully than those with an impulsive cognitive style, which in turn influences their understanding of science (Effendi et al., 2021). At the stage of student orientation on problems, the teacher provides problems related to science learning that are connected to the surrounding environment. Students understand and analyze problems presented by teachers that require solutions.

This problem-based learning model is triggered by a problem that exists in the lives of students, who will investigate the problem to find a solution (Samadun & Dwikoranto, 2022). At the stage of guiding individual and group investigations, the teacher's role is to encourage students to collect appropriate information and conduct experiments to solve the problems (Ekaningsih, 2021). When students carry out an experimental process to solve problems, it provides them with valuable experience. It presents interesting opportunities for students during the investigation process, fostering the development of independent thinking, critical thinking, reasoning, and scientific perspectives (Kaneza et al., 2024). Students correct their misconceptions about their initial understanding of the problem presented by the teacher by testing it experimentally, thereby deepening their understanding of the science learning material (Parthasarathy, 2023). Students with a reflective cognitive style will understand science differently from students with an impulsive cognitive style because students with a reflective cognitive style will observe and ask questions first before solving problems related to science learning so that they are not in a hurry to make decisions and for students with an impulsive cognitive style, they immediately experiment without asking and looking for sources of data needed to carry out experiments and seek understanding of the results of the experiments they have carried out. Students in the impulsive group tend to make decisions quickly, despite their low accuracy, and often fail to consider the consequences of their actions. The impulsive group tends to think reflectively when understanding and reflecting on procedural strategies, while reflective students tend to think reflectively regarding the stages of reflection and critical reflection, often with the guidance of strategy experts (Parthasarathy, 2023).

This problem-based learning model also actively invites students to learn science, where students work together in groups to solve the problems given, so that students can solve problems gradually and can understand science, which has an impact on students' scientific literacy, which will form itself in the learning process (Nainggolan et al., 2021). Students with a reflective cognitive style will carefully develop ways or strategies to solve problems based on sources of information or data they obtain through asking questions and reading books. In contrast, students with an impulsive cognitive style do not have time to create strategies or ways to solve problems. Because these students will quickly decide to solve problems based on their basic understanding, they often make mistakes in the implementation process. The implications for educational practice are significant. Educators who wish to implement PBL should consider incorporating diagnostic assessments of cognitive styles to identify students who may need additional scaffolding. For impulsive students, PBL can be adapted by breaking problems into smaller steps, providing explicit strategic guidance, and structuring group work to encourage more reflective participation. Future research should explore PBL strategies and investigate whether similar interaction effects exist with other cultural contexts or different cognitive dimensions.

CONCLUSION

This study concludes that a Problem-Based Learning (PBL) model integrated with Balinese local wisdom is effective in reducing misconceptions and enhancing scientific literacy, especially for students with a reflective cognitive style. The MANOVA results confirmed significant main effects of both learning model and cognitive style, as well as their interaction, demonstrating that the effectiveness of instructional approaches depends on the alignment between pedagogy and students' cognitive processing styles. Beyond these findings, several practical implications emerge. For teachers, integrating local wisdom into science instruction can make learning more meaningful and contextually relevant, while diagnosing students' cognitive styles allows teachers to tailor strategies. Reflective students can be optimally supported through structured PBL stages that encourage careful analysis and reflection. At the same time, impulsive students may benefit from additional scaffolding such as breaking problems into smaller steps, providing explicit prompts for reflection, and offering guided practice to manage cognitive load. For policymakers and curriculum developers, the study emphasizes the importance of systematically integrating cultural contexts into science curricula and providing teacher training that addresses cognitive diversity. Such initiatives will not only strengthen conceptual understanding but also support the achievement of SDG 4 on Quality Education in Indonesia.

REFERENCES

Aini, S. N., & Wiryanto. (2020). Analisis Miskonsepsi Matematika Siswa Pada Materi Operasi Hitung Pecahan Desimal Kelas V Di Sekolah Dasar. *Jpgsd*, *8*(2), 341–351.

Amin, S., Utaya, S., Bachri, S., Sumarmi, S., & Susilo, S. (2020). Effect of problem based learning on critical thinking skill and enviromental attitude. *Journal for the Education of Gifted Young Scientists*, *8*(2), 743–755.

Anggreni, N. K. D., Margunayasa, I. G., & Jayanta, I. N. L. (2023). Problem Based Learning Model and Cognitive Style on Science Literacy in Fifth Grade Elementary School Students. *Mimbar Ilmu*, *28*(2).

Ardianto, D., & Rubini, B. (2016). Comparison Of Students'scientific Literacy In Integrated Science Learning Through Model Of Guided Discovery And Problem Based Learning. *Jurnal Pendidikan IPA Indonesia*, *5*(1), 31–37.

Armstrong, S. J., Peterson, E. R., & Rayner, S. G. (2012). Understanding and defining cognitive style and learning style: a Delphi study in the context of educational psychology. *Educational Studies*, *38*(4), 449–455.

Aryawati, P. A. (2020a). Pengaruh Model Problem Based Learning Terhadap Keterampilan Berpikir Kritis Dalam Pembelajaran Biologi Ditinjau Dari Gaya Kognitif Siswa Kelas X SMA. *Wahana Matematika Dan Sains: Jurnal Matematika, Sains, Dan Pembelajarannya*, *14*(2), 105–124.

Aryawati, P. A. (2020b). Pengaruh Model Problem Based Learning Terhadap Keterampilan Berpikir Kritis Dalam Pembelajaran Biologi Ditinjau Dari Gaya Kognitif Siswa Kelas X SMA. *Wahana Matematika Dan Sains: Jurnal Matematika, Sains, Dan Pembelajarannya*, *14*(2), 105–124.

Astawan, I. G., Suarjana, I. M., Werang, B. R., Asaloei, S. I., Sianturi, M., & Elele, E. C. (2023). STEM-Based Scientific Learning and Its Impact on Students' Critical and Creative Thinking Skills: An Empirical Study. *Jurnal Pendidikan IPA Indonesia*, *12*(3), 482-492.

Astawan, I G., Sudana, D. N., Kusmariyatni, N., & Japa, I G. N. (2019). The STEAM Integrated Panca Pramana Model in Learning Elementary School Science in The Industrial Revolution Era 4.0. *International Journal of Innovation, Creativity and Change*, *5*(5), 26-39.

Chen, C., Sonnert, G., Sadler, P. M., & Sunbury, S. (2020). The impact of high school life science teachers' subject matter knowledge and knowledge of student misconceptions on students' learning. *CBE Life Sciences Education*, *19*(1).

Creswell, J. W., & Creswell, J. D. (2018). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. SAGE Publications. https://books.google.co.id/books?id=s4ViswEACAAJ

Desstya, A., Prasetyo, Z. K., & Susila, I. (2019). Developing an Instrument to Detect Science Misconception of an Elementary School Teacher. *International Journal of Instruction*, *12*(3), 201–218.

Effendi, D. N., Anggraini, W., Jatmiko, A., Rahmayanti, H., Ichsan, I. Z., & Rahman, M. M. (2021). Bibliometric analysis of scientific literacy using VOS viewer: Analysis of science education. *Journal of Physics: Conference Series*, *1796*(1), 12096.

Ekaningsih, R. (2021). Problem Based Learning to Develop Critical Thinking Patterns and Improve Contextual Problem-Solving Skills. *Social, Humanities, and Educational Studies (SHES): Conference Series*, *4*(5), 721–726.

Fadiana, M. (2015). Math Learning Model That Accommodates Cognitive Style to Build Problem-Solving Skills. *Higher Education Studies*, *5*(4), 86–98.

Fadillah, L., Kartono, K., & Supriyadi, S. (2019). Peran Tutor Feedback dalam Model PBL pada Pencapaian Kemampuan Komunikasi Matematis ditinjau dari Gaya Kognitif. *PRISMA, Prosiding Seminar Nasional Matematika*, *2*, 533–539.

Fauziah, A. N. M., Hendratmoko, A. F., Mahdiannur, M. A., Ermawan, M. Z. F., Suwandi, E., & Ratri, S. Y. (2024). Relationship Between Critical Thinking and Scientific Argumentation in Science Learning. *Jurnal Pendidikan IPA Indonesia, 13*(2).

Fıtrıanı, A., Zubaıdah, S., Susılo, H., & Al Muhdhar, M. H. İ. (2020). The effects of integrated problem-based learning, predict, observe, explain on problem-solving skills and self-efficacy. *Eurasian Journal of Educational Research*, *20*(85), 45–64.

Galvin, E., Simmie, G. M., & O'Grady, A. (2015). Identification of misconceptions in the teaching of biology: A pedagogical cycle of recognition, reduction and removal. *Higher Education of Social Science*, *8*(2), 1–8.

Garg, S., Tsipras, D., Liang, P., & Valiant, G. (2022). *What Can Transformers Learn In-Context? A Case Study of Simple Function Classes*. https://github.com/dtsip/in-context-learning.

Harahap, F., Nasution, N. E. A., & Manurung, B. (2019). The effect of blended learning on student's learning achievement and science process skills in plant tissue culture course. *International Journal of Instruction*, *12*(1), 521–538.

Harun, N. F., Yusof, K. M., Jamaludin, M. Z., & Hassan, S. A. H. S. (2012). Motivation in problem-based learning implementation. *Procedia-Social and Behavioral Sciences*, *56*, 233–242.

Hayati, N., Adriana, E., & Syachruroji, A. (2022). Analisis miskonsepsi siswa pada konsep ipa kelas iv di sd negeri majalaya (Kecamatan Tunjungteja, Kabupaten Serang). *Jurnal Handayani Pgsd Fip Unimed*, *13*(1), 146–152.

Herlina, S., & Kelana, J. B. (2021). Pemahaman Konsep Bentuk Dan Fungsi Bagian Tumbuhan Melalui Model Pembelajaran Problem Based Learning Siswa Kelas IV SD. *COLLASE (Creative of Learning Students Elementary Education)*, *4*(3), 421–427.

Ikstanti, V. M., & Yulianti, Y. (2023). Pengaruh Model Pembelajaran Problem Based Learning (PBL) terhadap Pemahaman Konsep IPA Siswa. *Papanda Journal of Mathematics and Science Research*, *2*(1), 40–48.

Imbar, M., & Winoto, D. E. (2024). The Process of Learning Through a Problem-Based Model Helps to Address and Correct Historical Misconceptions. *International Journal of Multicultural and Multireligious Understanding*, *11*(3), 146–157.

Indrawan, I. P. O., & Mahendra, I. G. J. (2021). E-Learning terintegrasi kearifan lokal Bali berbasis 4c pada mata pelajaran IPA. *Jurnal Pedagogi Dan Pembelajaran*, *4*(3), 511–521.

Islami, E., Zaky, R. A., & Nuangchalerm, P. (2020). Comparative Study of Scientific Literacy: Indonesian and Thai Pre-Service Science Teachers Report. *International Journal of Evaluation and Research in Education*, *9*(2), 261–268.

Jelatu, S., Kurniawan, Y., Kurnila, V. S., Mandur, K., & Jundu, R. (2019). Collaboration TPS Learning Model and m-Learning Based on Android for Understanding of Trigonometry Concepts with Different Cognitive Style. *International Journal of Instruction*, *12*(4), 545–560.

Kalmatova, G., Duishonbekova, G., Moldobaeva, D., Guseinova, Z., & Orozaliev, E. (2024). Influence of cognitive styles on students' research activities. *Scientific Herald of Uzhhorod University Series Physics*, *56*, 2230–2239.

Kaneza, P., Nkurunziza, J. B., Twagilimana, I., Mapulanga, T., & Bwalya, A. (2024). Analysis of conceptual understanding of solutions and titration among Rwandan secondary school students. *Cogent Education*, *11*(1), 2315834.

Khoiriyah, U., Roberts, C., Jorm, C., & Van der Vleuten, C. P. M. (2015). Enhancing students' learning in problem based learning: validation of a self-assessment scale for active learning and critical thinking. *BMC Medical Education*, *15*, 1–8.

Khotimah, R. P. (2017). Student Misconceptions in Solving Real Analysis Problem Based on Reasoning Framework. *Proceeding ICMETA*, *1*(1), 70–75.

Kirschner, P. (2019). *Decision letter for "Studying the effectiveness of an online argumentation model for improving undergraduate students' argumentation ability"*. Wiley.

Kozhevnikov, M., Ho, S., & Koh, E. (2022). The role of visual abilities and cognitive style in artistic and scientific creativity of Singaporean secondary school students. *The Journal of Creative Behavior*, *56*(2), 164–181.

Maknun, J. (2020). Implementation of Guided Inquiry Learning Model to Improve Understanding Physics Concepts and Critical Thinking Skill of Vocational High School Students. *International Education Studies*, *13*(6), 117–130.

Margunayasa, I. G., Dantes, N., Marhaeni, A., & Suastra, I. W. (2019). The Effect of Guided Inquiry Learning and Cognitive Style on Science Learning Achievement. *International Journal of Instruction*, *12*(1), 737–750.

Marlissa, I., & Widjajanti, D. B. (2015). Pengaruh strategi REACT ditinjau dari gaya kognitif terhadap kemampuan pemecahan masalah, prestasi belajar dan apresiasi siswa terhadap matematika. *Jurnal Riset Pendidikan Matematika*, *2*(2), 186–196.

Martawijaya, M. A., Rahmadhanningsih, S., Swandi, A., Hasyim, M., & Sujiono, E. H. (2023). The Effect of Applying the Ethno-STEM-Project-based Learning Model on Students' Higher-order Thinking Skill and Misconception of Physics Topics Related to Lake Tempe, Indonesia. *Jurnal Pendidikan IPA Indonesia*, *12*(1), 1–13.

Maryati, I. (2018). Penerapan model pembelajaran berbasis masalah pada materi pola bilangan di kelas vii sekolah menengah pertama. *Mosharafa: Jurnal Pendidikan Matematika*, *7*(1), 63–74.

Masfuah, S., & Fakhriyah, F. (2021). Profile of student misconceptions: limited scale trial of diagnostic assessment development based on science literacy. *Journal of Physics: Conference Series*, *1918*(5), 52080.

Maulana, G., Zaenuri, Z., & Junaedi, I. (2020). Pattern of Problem Solving Skill Reviewed Based on Student Cognitive Style After Experienced Problem Based Learning Model with Ethnomathematics Nuances. *Journal of Primary Education*.

Muttaqin, W. M. (2020). Integrating Instruction Approach with Learners' Cognitive Style to Enhance EFL Indonesian Students' Writing Achievement. *International Journal of Instruction*, *13*(1), 623–636.

Nafiah, Y. N., & Suyanto, W. (2014). Penerapan Model Problem Based Learning untuk Meningkatkan Keterampilan Berpikir Kritis dan Hasil Belajar Siswa. *Jurnal Pendidikan Vokasi*, *4*(1), 125–143.

Nainggolan, V. A., Situmorang, R. P., & Hastuti, S. P. (2021). Learning Bryophyta: Improving Students' Scientific Literacy through Problem-Based Learning. *Journal of Biological Education Indonesia (Jurnal Pendidikan Biologi Indonesia)*, *7*(1), 71–82.

Nasution, M. L., Yerizon, Y., & Gusmiyanti, R. (2018). Students' mathematical problem-solving abilities through the application of learning models problem based learning. *IOP Conference Series: Materials Science and Engineering*, *335*(1), 12117.

Norazilawati, A. U. (2023). Pembelajaran Berbasis Kearifan Lokal Tanaman Faloak (Sterculia Quadrifida R.Br) Terhadap Literasi Sains Siswa Kelas IV Sekolah Dasar Oeba 3 Kota Kupang. *Jurnal Pendidikan Dasar Flobamorata*, *4*(1), 489–494.

Nurtanto, M., Nurhaji , S., Widjanarko, D., Wijaya, M. B. R., & Sofyan, H. (2018). Comparison of scientific literacy in engine tune-up competencies through guided problem-based learning and non-integrated problem-based learning in vocational education. *Journal of Physics: Conference Series*, *1114*(1), 12038.

Parthasarathy, J. (2023). Content analysis of Biology textbooks across selected educational boards of Asia for misconceptions and elements of conceptual change towards learning 'Cell Structure.' *Cogent Education*, *10*(2), 2283640.

Pei, B. (2019). Using automatic image processing to analyze visual artifacts created by students in scientific argumentation. *British Journal of Educational Technology*, *50*(6), 3391–3404.

Rahmatina, S., Sumarmo, U., & Johar, R. (2014). Tingkat Berpikir Kreatif Siswa dalam Menyelesaikan Masalah Matematika Berdasarkan Gaya Kognitif Reflektif dan Impulsif. *Jurnal Didaktik Matematika*, *1*(1), 62–70.

Rahmaveira, N. A., & Ardianti, S. D. (2024). Pengaruh Modul Problem Based Learning Berbantuan Media Augmented Reality Berbasis Kearifan Lokal Gusjigang Terhadap Pemahaman Konsep IPA SD 3 Barongan. *Didaktik: Jurnal Ilmiah PGSD STKIP Subang*, *10*(1), 1507–1514.

Rahmawati, Y., Hartanto, O., Falani, I., & Iriyadi, D. (2022). Students' Conceptual Understanding in Chemistry Learning Using PhET Interactive Simulations. *Journal of Technology and Science Education*, *12*(2), 303–326.

Restiani, N. L. D., Margunayasa, I. G., & Paramita, M. V. A. (2023). Improving Scientific Literacy of Elementary School Students through Problem-Based Learning Model with Balinese Local Wisdom. *Jurnal Ilmiah Sekolah Dasar*, *7*(4).

Riding, R., & Rayner, S. (2013). *Cognitive styles and learning strategies: Understanding style differences in learning and behavior*. David Fulton Publishers.

Rozi, F., & Prawijaya, S. (2019). The development of problem-based learning model with scientific literacy approach in elementary school. *1st International Conference on Social Sciences and Interdisciplinary Studies (ICSSIS 2018)*, 230–233.

Rudolph, J. L. (2024). Scientific literacy: Its real origin story and functional role in American education. *Journal of Research in Science Teaching*, *61*(3), 519–532.

Rusmansyah, R., Leny, L., & Sofia, H. N. (2023). Improving students' scientific literacy and cognitive learning outcomes through ethnoscience-based PjBL model. *Journal of Innovation in Educational and Cultural Research*, *4*(1), 1–9.

Saefullah, A., Samanhudi, U., Nulhakim, L., Berlian, L., Rakhmawan, A., Rohimah, B., & El Islami, R. A. Z. (2017). Efforts to improve scientific literacy of students through guided inquiry learning based on local wisdom of Baduy's society. *Jurnal Penelitian Dan Pembelajaran IPA*, *3*(2), 84–91.

Salido, A., Suryadi, D., Dasari, D., & Muhafidin, I. (2020). Mathematical reflective thinking strategy in problem-solving viewed by cognitive style. *Journal of Physics: Conference Series*, *1469*(1), 12150.

Samadun, S., & Dwikoranto, D. (2022). Improvement of student's critical thinking ability sin physics materials through the application of problem-based learning. *IJORER: International Journal of Recent Educational Research*, *3*(5), 534–545.

Sanjayanti, N. P. A. H., Suastra, I. W., Suma, K., & Adnyana, P. B. (2022). Effectiveness of science learning model containing balinese local wisdom in improving character and science literacy of Junior High School students. *International Journal of Innovative Research and Scientific Studies*, *5*(4), 332–342.

Saputra, M. D., Joyoatmojo, S., Wardani, D. K., & Sangka, K. B. (2019). Developing critical-thinking skills through the collaboration of jigsaw model with problem-based learning model. *International Journal of Instruction*, *12*(1), 1077–1094.

Saputri, L. A., Muldayanti, N. D., & Setiadi, A. E. (2016). Analisis Miskonsepsi Siswa dengan Certainty of Response Index (CRI) pada Submateri Sistem Saraf di Kelas XI IPA SMA Negeri 1 Selimbau. *Jurnal Bioeducation*, *3*(2), 53–62.

Sari, D. M. M., & Prasetyo, Y. (2021). Project-based-learning on critical reading course to enhance critical thinking skills. *Studies in English Language and Education*, *8*(2), 442–456.

Savery, J. R. (2015). Overview of problem-based learning: Definitions and distinctions. *Essential Readings in Problem-Based Learning: Exploring and Extending the Legacy of Howard S. Barrows*, *9*(2), 5–15.

Sellah, L., Jacinta, K., & Helen, M. (2017). Analysis of Student-Teacher Cognitive Styles Interaction: An Approach to Understanding Learner Performance. *Journal of Education and Practice*, *8*(14), 10–20.

Septiani, D. R., & Purwanto, S. E. (2020). Hubungan Antara Kepercayaan Diri dengan Hasil Belajar Matematika Berdasarkan Gender. *JKPM (Jurnal Kajian Pendidikan Matematika)*, *6*(1), 141–148.

Simbolon, R., & Koeswanti, H. D. (2020). Comparison of Pbl (Project Based Learning) models with Pbl (Problem Based Learning) models to determine student learning outcomes and motivation. *International Journal of Elementary Education*, *4*(4), 519–529.

Sockalingam, N., & Schmidt, H. G. (2011). Characteristics of problems for problem-based learning: The students' perspective. *Interdisciplinary Journal of Problem-Based Learning*, *5*(1), 6–33.

Suliyanah, Putri, H. N. P. A., & Rohmawati, L. (2018). Identification student's misconception of heat and temperature using three-tier diagnostic test. *Journal of Physics: Conference Series*, *997*(1).

Suprapto, N. (2020). Do we experience misconceptions?: An ontological review of misconceptions in science. *Studies in Philosophy of Science and Education*, *1*(2), 50–55.

Surur, M., Degeng, I., 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.

Susiloningsih, W., Susilo, H., Zainuddin, M., Kuswandi, D., Suciptaningsih, O. A., & Faizah, H. (2024). The effect of cognitive style on the analysis ability of grade 4 elementary school students. *JPPI (Jurnal Penelitian Pendidikan Indonesia)*, *10*(2), 490–495.

Tan Sisman, G., & Aksu, M. (2016). A study on sixth grade students' misconceptions and errors in spatial measurement: Length, area, and volume. *International Journal of Science and Mathematics Education*, *14*, 1293–1319.

Tomlinson, K. (2017). *Energy poverty: SOS*. commons.lib.jmu.edu. https://commons.lib.jmu.edu/cgi/viewcontent.cgi?referer=&httpsredir=1&article=1392&context=honors201019

Utami, R. E., & Indriana, K. (2018). Metacognitive ability of male students: difference impulsive-reflective cognitive style. *Journal of Physics: Conference Series*, *983*(1), 12118.

Vosniadou, S. (2019). The Development of Students' Understanding of Science. *Frontiers in Education*, *4*.

Vosniadou, S., & Skopeliti, I. (2014). Conceptual change from the framework theory side of the fence. *Science & Education*, *23*, 1427–1445.

Wilcox, M. J., Gray, S., & Reiser, M. (2020). Preschoolers with developmental speech and/or language impairment: Efficacy of the Teaching Early Literacy and Language (TELL) curriculum. *Early Childhood Research Quarterly*. https://www.sciencedirect.com/science/article/pii/S0885200619301292

Wolk, S. (2022). Clearing up misconceptions about project-based learning. *Phi Delta Kappan*, *104*(2), 26–31.

Yew, E. H. J., & Goh, K. (2016). Problem-based learning: An overview of its process and impact on learning. *Health Professions Education*, *2*(2), 75–79.

Yuliati, Y. (2017). Miskonsepsi siswa pada pembelajaran IPA serta remediasinya. *Bio Educatio*, *2*(2), 279470.

Разумникова, О. М. (2024). The Role of Cognitive Style in the Formation of Personalized Learning Programs. Ministry of Science and Higher Education of the Russian Federation Federal State Budgetary Educational Institution of Higher Education "Yelets State University named after Ia Bunin." 60.