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Numeracy literacy outcomes of RME with local wisdom across cognitive styles

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ABSTRACT

Numeracy literacy is a crucial skill involving the use of numbers, symbols, and basic mathematical concepts in daily life. However, PISA results indicate that Indonesian students' numeracy literacy remains low, highlighting the need for effective learning models. This study examined the integration of the Realistic Mathematics Education (RME) model with Kudus local wisdom to enhance students' numeracy literacy, taking into account their cognitive styles. Kudus local wisdom encompasses traditions such as Dandangan and local products like parijoto fruit, jenang, batik, sarongs, and embroidered kebaya. The research involved seventh-grade students at a state junior high school in Kudus and employed a quantitative quasi-experimental design with a 2×2 factorial arrangement. The Group Embedded Figures Test (GEFT) was used to identify students' cognitive styles, while a numeracy literacy test measured learning outcomes. Data were analyzed using two-way ANOVA. The results showed that: (1) the RME model significantly improved numeracy literacy ($p = 0.011$); (2) cognitive style did not have a significant effect on numeracy literacy ($p = 0.615$); and (3) there was no significant interaction between learning model and cognitive style ($p = 0.272$). In conclusion, the RME model effectively enhances numeracy literacy regardless of students' cognitive styles. Its integration with local wisdom not only supports student competencies but also aligns with the Merdeka Curriculum's vision of meaningful learning and contributes to achieving the Pancasila Student Profile.

KEYWORDS

Literacy; numeracy; RME; Kudus local wisdom; cognitive styles

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INTRODUCTION

Jailani, et.al. (2020) stated that literacy is a fundamental ability that enables individuals to participate in society and achieve their goals in both work and life. Traditionally, literacy was defined as a person's ability to read and write simple statements about their daily lives. However, over time, the concept of literacy has evolved beyond reading and writing to include intellectual abilities, as well as the capacity to conduct research and solve complex problems (Jailani et al., 2020). One essential form of literacy that students must master is numeracy literacy. Numeracy literacy refers to a person's ability to formulate, identify, understand, and apply basic mathematical concepts in various contexts relevant to daily life (Fauzan et al., 2024).

Indonesia has participated in the Programme for International Student Assessment (PISA) since 2000 to assess students' literacy skills. However, PISA results indicate that

Indonesian students' numeracy literacy remains relatively low. Figure 1 presents the numeracy literacy achievement of Indonesian students based on the latest PISA results (Wijaya et al., 2024).

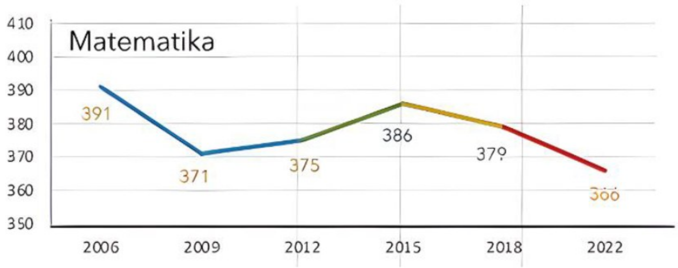

Figure 1. Indonesian mathematics scores in PISA from 2006 to 2022

Figure 1 shows that Indonesian students obtained the lowest mathematics score in PISA 2022, which was 366—well below the OECD average of 472 (OECD, 2023). Participation in PISA allows Indonesia to monitor and compare the quality of its education system with other countries over time. At PISA 2022, Indonesia ranked 70th out of 81 participating countries (Wijaya et al., 2024).

The main factors contributing to students' low mathematical literacy include learning models and assessment items that are less focused on numeracy skills, as well as internal factors such as students' self-confidence and prior knowledge (Sulfayanti, 2023). Students often face challenges in mathematical processes due to weak numeracy literacy, exacerbated by teachers who rarely encourage active participation in mathematics (Fauzan et al., 2024). Abdullah (2024) notes that low literacy skills lead many students to struggle with mathematics, particularly when dealing with real-world problems presented in varied formats. Similarly, Astriani and Akyuni (2024),highlight that students with low numeracy literacy experience confusion in solving contextual problems and analyzing initial information, hindering accurate decision-making..

Numeracy literacy is closely linked to students' cognitive processes. In developing critical thinking, individuals exhibit preferred methods for processing information and experiences, known as cognitive styles (Izzatin et al., 2020). ognitive psychologists define cognitive style as an individual's characteristic way of perceiving, thinking, remembering, and using information to solve problems. The Field-Independent (FI) and Field-Dependent (FD) cognitive styles were originally conceptualized by Herman A. Witkin and his colleagues (Witkin et al., 1977). FI individuals tend to think analytically, focusing on specific details while often disregarding contextual information. In contrast, FD individuals perceive information more holistically, relying on contextual and social cues during problem-solving. These cognitive styles influence learning, problem-solving, and social interactions (Farmaki et al., 2019; Wu, 2018).

Students' cognitive development can be optimized if learning models align with their characteristics. As a skill applied in daily life, numeracy literacy benefits from contextualized learning approaches. Students gain deeper understanding when mathematics is connected to their experiences, not just abstract concepts. Realistic Mathematics Education (RME) exemplifies this approach by beginning with real contexts and students' prior experiences (Apsari et al., 2020; Saleh et al., 2018; Son et al., 2020).

In addition to cognitive development, Indonesia's education system emphasizes character building. Character education shapes students' behavior, discipline, moral values, and academic growth. Local wisdom, rooted in daily life, provides a tool for problem-solving and instills values important for character development (Kurnianto & Lestarini, 2016; Sembiring et al., 2019). The concept of local wisdom encompasses the values, norms, and practices cherished by communities, serving as a guide for interpersonal relationships and personal life goals, thereby forming a strong foundation for character education in schools (Yusuf, 2023). Effective integration of local wisdom in curricula requires incorporating it into books, modules, teaching materials, methodologies, and learning models (Toharudin et al., 2020).

Local wisdom is a perspective on life, knowledge, and ways of living that local communities use to solve problems and meet their needs (Agustina et al., 2021) It is crucial in mathematics learning because it helps students understand mathematical concepts contextually, strengthens their cultural identity, and increases motivation and interest in learning. By linking mathematical concepts to students' culture and everyday experiences, local wisdom serves as a valuable enrichment for learning materials (Harefa, 2024). In Indonesia, local wisdom exists across all regions, including Kudus Regency in Central Java. Examples of local wisdom in Kudus include historical landmarks such as Menara Kudus, traditional cultural events like Dandangan and Buka Luwur, and unique agricultural products such as parijoto fruit. Distinctive community products include jenang, batik, sarongs, and intricately embroidered kebayas. Integrating Kudus local wisdom with the RME model can help students understand mathematical concepts within their cultural and environmental context, fostering both academic knowledge and an

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appreciation of local customs and sustainability principles. For instance, Menara Kudus can be used to teach plane geometry and spatial reasoning, as illustrated in Figure 2 (Rahmawati et al., 2021).

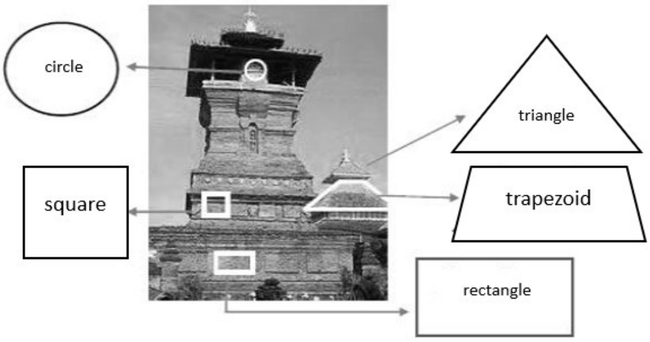

Figure 2. The Concept of Geometry in the Local Wisdom of Menara Kudus

Previous research by Agustina (2021) developed realistic mathematics problems based on local wisdom from Sidoarjo, while Putri (2022) conducted a design and research project on implementing ethnomathematics-based RME learning for fractions using the context of Spiku cake. In this study, RME learning was integrated with local wisdom from Kudus, and an experimental design was employed to assess its impact on students' numeracy literacy. Cognitive style, a psychological factor influencing problem-solving approaches, remains understudied in numeracy contexts, making it a critical variable for investigation (Khunaeni et al., 2024). By combining RME with culturally familiar elements and considering individual cognitive styles, this study aims to advance learning models that both strengthen numeracy skills and accommodate student diversity. The outcomes could provide valuable guidance for educators designing context-responsive mathematics curricula.

METHODS

This study employed a quasi-experimental design using a 2×2 factorial arrangement. The study design is described as shown in Table 1.

Table 1. 2x2 factorial design

Cognitive Style (B)	Learning Model (A)	
	RME (A1)	Expository (A2)
Field Independent (B1)	A1B1	A2B1
Field Dependent (B2)	A1B2	A2B2

Explanation:
A1B1: A group of students with Field Independent (FI) cognitive style was treated using the RME model.
A1B2: A group of students with Field Dependent (FD) cognitive style was treated using the RME model.
A2B1: A group of students with Field Independent (FI) cognitive style was treated using the expository model.
A2B2: A group of students with Field Dependent (FD) cognitive style was treated using the expository model.

Population and Research Sample

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The population in this study consisted of all Year 7 students at a state junior high school in Kudus. The sampling technique used was simple random sampling. Two classes were randomly selected from all available classes. Subsequently, a random draw determined which class would serve as the experimental group and which as the control group. Class VII-A, comprising 28 students, was assigned as the experimental class and received the RME model treatment (A1), while Class VII-G, comprising 26 students, served as the control class and received the expository model treatment (A2). Students in both the RME (A1) and Expository (A2) classes were further classified according to their cognitive styles: Field Independent (B1) and Field Dependent (B2). The classification of students' cognitive styles in the RME and Expository classes is presented in Table 2.

Table 2. Classification of students' cognitive styles

Grade	Category	RME (A1)		Expository (A2)	
		F	Percentage	F	Percentage
$10 \leq x < 19$	FI (B1)	10	35.71	17	65.38
$0 \leq x < 10$	FD (B2)	18	64.29	9	34.62
Total		28	100	26	100

Instruments

The instruments used in this study consisted of a numeracy literacy test and the Group Embedded Figures Test (GEFT). The numeracy literacy test measured students' numeracy literacy skills, while the GEFT was used to classify students according to their cognitive styles.

Numeracy Literacy Test

The numeracy test used in this study consists of three descriptive questions designed to assess students' numeracy literacy skills. Validation was conducted by consulting five experts, who determined that the instrument was suitable for use. Following content validation, a pilot test was conducted, which showed that all three items were valid and that the instrument had a reliability coefficient of 0.81, indicating a very high level of reliability. Numeracy literacy was evaluated through specific process indicators, including: (1) formulating situations mathematically, (2) employing mathematical concepts, facts, procedures, and reasoning, and (3) interpreting, applying, and evaluating mathematical results (OECD, 2019). Assessment was conducted using a scoring rubric, with each indicator scored from 0 to 3. The numeracy literacy questions tested are detailed in Table 3.

Table 3. Numeracy Literacy Test Questions

Test Item	Question
1	A fruit trader buys two boxes of parijoto fruit, each weighing 1 quintal, with a tare of 2.5%. The purchase price of each box is Rp 1,000,000.00. If the parijoto fruit is sold at

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Test Item	Question
	Rp 12,000.00 per kilogram, what profit does the trader make?
2	Mr. Agus is an UMKM entrepreneur who produces Jenang Kudus. At the beginning of 2020, he deposited Rp 1,500,000.00 in a cooperative with a simple interest rate of 4% per year. At the end of October 2020, Mr. Agus withdrew all his savings to cover production costs of Rp 1,400,000.00 for Jenang Kudus. If the UMKM tax rate applied to him is 5%, will any money remain from his savings? If so, how much?
3	Zira is going shopping at the 'Laris' store in Kliwon Market to buy an embroidered kebaya and Kudus batik cloth. She finds an embroidered kebaya priced at Rp 350,000.00 and has a voucher worth Rp 85,000.00, applicable for purchases of at least Rp 300,000.00. She then looks for Kudus batik cloth and finds one priced at Rp 200,000.00 with a 20% discount. According to store policy, Zira can only use one type of discount, not both. Which option will allow Zira to pay less: the voucher or the discount?

Group Embedded Figures Test (GEFT)

The Group Embedded Figures Test (GEFT) was developed by Philip K. Oltman, Evelyn Raskin, and Herman A. Witkin in 1977 (Witkin et al., 1977). The GEFT is designed to assess cognitive styles, specifically focusing on Field Independent (B1) and Field Dependent (B2) styles. The test consists of tasks that require individuals to identify simple shapes embedded within complex figures, thereby evaluating their ability to discern relevant information amid distracting stimuli. According to Witkin, the GEFT is a valid and reliable instrument, with a reported reliability coefficient of 0.82, and it has been extensively used in research settings.

Data Analysis

Assumption tests are conducted to determine whether the sample data meet the required conditions. In this study, the assumption tests include a normality test and a homogeneity test. The normality test, using the Shapiro-Wilk method, is conducted to determine whether the data distribution is normal. This test is highly effective and valid, particularly for small samples, typically consisting of fewer than 50 data points (Sianturi, 2025). The homogeneity test, using Levene's test, assesses whether samples drawn from the same population are homogeneous. Levene's test is preferred because it is more flexible and does not require the assumption of normally distributed data (Sianturi, 2022).

Once the assumption tests are satisfied, data analysis proceeds with hypothesis testing. Data were analyzed using a two-way ANOVA, which aimed to evaluate the effects of different learning models and cognitive styles on students' numeracy literacy. Two-way ANOVA is appropriate because the two independent variables (learning models and cognitive styles) are categorical, while the dependent variable (numeracy literacy) is measured on an

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interval or ratio scale (Yerizon et al., 2023). The analysis was conducted at a significant level of 0.05.

RESULT AND DISCUSSION

In the RME (Realistic Mathematics Education) model, students begin learning with real-life problems or everyday situations. They are asked to solve contextual problems to enhance their mathematical knowledge. This approach allows local wisdom to be integrated into the learning context, making it easier for students to understand and solve mathematical problems (Dosinaeng et al., 2025). Kudus' local wisdom is incorporated into the contextual problems presented during the RME learning process. This integration involves several key steps: first, understanding the contextual problem; second, explaining it to ensure all participants have a clear grasp; third, actively engaging students in solving the problem; fourth, comparing and discussing their solutions to foster deeper insights and critical thinking; and finally, drawing conclusions from these discussions.

The numeracy literacy skills of students in the experimental group are compared with those in the control group, as presented in Table 4.

Table 4. Students' numeracy literacy in each group

Cognitive Style (B)	Average numeracy literacy score	
	RME (A1)	Expository (A2)
Field Independent (B1)	70.00	62.32
Field Dependent (B2)	72.45	55.99

Table 4 shows that the use of the RME method increased the average numeracy literacy scores of students with both Field Independent (FI) and Field Dependent (FD) cognitive styles compared to the expository method. In the RME class, FD students achieved higher average numeracy literacy scores than FI students, whereas in the expository class, FI students demonstrated better mastery of numeracy literacy than FD students. The mastery of numeracy literacy skills in each group is illustrated in Figure 3.

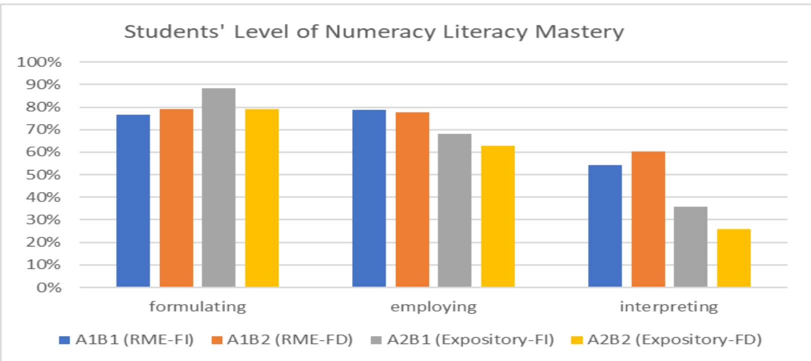

Figure 3. Students' Achievement on Each Numeracy Literacy Indicator

The levels of numeracy literacy mastery for FD and FI students in both the RME and

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expository classes were largely similar. All four groups demonstrated strong ability at the formulation stage, exceeding the 75% threshold. Students in the expository class with an FI cognitive style had the highest ability, achieving over 80%, while the other three groups showed comparable performance. This indicates that students possess a good ability to represent real-world situations mathematically.

At the employing stage, students in the RME FI and FD classes achieved mastery above 70%, whereas students in the expository classes remained below this level. At the interpretation stage, none of the four groups reached a mastery level of 70%. FI and FD students in the RME classes achieved mastery rates above 50%, while expository students lagged further behind. These results suggest that the ability to interpret, apply, and evaluate mathematical results still requires improvement.

These findings are consistent with the research of Nurmasari et al., (2024), which found that students scored higher on the formulating aspect of numeracy literacy than on the employing aspect, and higher on the employing aspect than on the interpretation aspect, both before and after learning. Similarly, Nurinayah & Nur, (2023), reported that while students can identify information in a problem, they often struggle to relate it to mathematical concepts or to interpret the results accurately.

The influence of learning models and cognitive styles on students' numeracy literacy was further examined through quantitative data analysis. Prior to conducting the two-way ANOVA test, prerequisite assumption tests—namely normality and homogeneity—were performed. The results of these tests are presented in Table 5.

Table 5. Prerequisite Assumption Test

Prerequisite Test	Type test		Sig.	Result
Normality test	Shapiro Wilk	Experiment class	0.224	Normally distributed data
		Control class	0.590	Normally distributed data
Homogenity test	Levene's Test		0.202	Homogeneous data variance

The data in Table 5 indicate that the distribution is normal and the variances are homogeneous. Therefore, a two-way ANOVA test was conducted, and the results are presented in Table 6.

Table 6. Two-way ANOVA test results

Source	Sum of Square	Df	Mean Square	F	Sig.	Result
Learning Model	1441.312	1	1441.312	6.947	0.011	Significant
Cognitive Style	53.238	1	53.238	0.257	0.615	Not significant
Learning model*Cognitive Style	255.441	1	255.441	1.231	0.272	Not significant

Based on the results of the two-way ANOVA test in Table 6, the hypothesis test can be described as follows. First, the ANOVA results show a significance value of 0.011 < 0.05, so the null hypothesis (H0), stating "there is no difference in numeracy literacy between students who follow the RME learning model and those who follow the expository learning model," is rejected. Thus, it can be concluded that numeracy literacy differs between students who follow the RME model and those who follow the expository model. Considering that the average numeracy literacy score of students in the RME model (71.62) is higher than that of students in the expository model (60.13), it can be concluded that the RME model has a positive and significant effect on students' numeracy literacy. Previous studies have similarly shown that students' numeracy literacy is higher in RME learning compared to direct instruction (Fauzan et al., 2024; Nurmasari et al., 2024; Sumirattana et al., 2017).

The RME learning model positively influences students' numeracy literacy because it begins with real-life context and students' experiences, facilitating the development of mathematical understanding. RME allows students to construct knowledge independently, promoting genuine comprehension and problem-solving skills. Incorporating elements of local wisdom is particularly beneficial, as familiar real-life contexts make mathematical concepts easier to grasp. As noted by Summirattana (2017), using real-life problems familiar to students enhances understanding and makes learning more meaningful.

The use of local wisdom in students' surroundings can serve as material in learning through the RME model. Situations that are close to students' daily lives make learning easier to understand. Integrating Kudus' local wisdom into mathematics learning allows students to relate mathematical concepts to cultural practices and traditions they are already familiar with, making the material more contextual, engaging, and relevant. This approach increases students' motivation and curiosity in learning. Research by Gómez Ferragud et al.,(2015). found that students have a greater ability to solve problems related to their everyday lives when the problem context is familiar. Familiarity with problem situations significantly affects the mental processes involved in problem-solving through analogical transfer. Students with low familiarity face difficulties in constructing structural analogies and filtering out irrelevant elements, largely due to the high cognitive demand required to mentally represent the entities mentioned in the problem.

Based on the two-way ANOVA results in Table 6, the second hypothesis test shows a significance value of 0.615 > 0.05. Therefore, H0, which states "there is no difference in numeracy literacy between students with FI and FD cognitive styles," is accepted. This indicates that cognitive style does not significantly influence students' numeracy literacy. Similarly, the third hypothesis test shows a significance value of 0.272 > 0.05, so H0, stating "the interaction between the learning model (A) and cognitive style (B) does not affect students' numeracy literacy," is also accepted. Thus, the interaction between learning model and cognitive style does not significantly influence numeracy literacy.

Numeracy literacy is defined as an individual's capacity to formulate, use, and interpret mathematics in various contexts. It includes reasoning mathematically and applying concepts, procedures, facts, and tools to describe, explain, and predict phenomena (OECD, 2013). Therefore, numeracy literacy requires not only mathematical proficiency but also the ability to understand problem contexts, enabling individuals to select appropriate mathematical procedures for problem resolution. FI and FD cognitive styles offer distinct approaches to thinking that support numeracy literacy.

FI and FD cognitive styles are based on preferences for processing internal and external information. Consequently, students with these cognitive styles are likely to employ strategies suited to their individual preferences, though each style exhibits distinct tendencies. To succeed in learning, students must develop skills that enhance their ability to learn effectively (Muhammad et al., 2015). Research by Sutama (Sutama et al., 2021) indicates that students with an FI cognitive style can efficiently identify and solve multiple components of a larger pattern by breaking it down into parts. In contrast, FD students often struggle to focus on specific aspects or analyze patterns independently. While this does not imply inherent limitations for FD students in solving mathematical problems, it highlights their reliance on external cues and contextual understanding rather than isolated component analysis. Therefore, each type of student requires different approaches to problem-solving and learning, underscoring the importance of adapting instructional methods to accommodate varying cognitive styles (Wu, 2018).

In this study, the RME model was implemented with local wisdom from Kudus Regency, focusing on social arithmetic. Further research is recommended to expand this approach to other mathematics topics, such as algebra, geometry, or statistics, and to integrate local wisdom from other regions to enrich learning contexts. Additionally, with the rapid development of technology and its growing importance in education, future studies should incorporate digital learning media, interactive applications, or online platforms to increase student engagement and motivation in learning mathematics contextually and meaningfully.

CONCLUSION

The study on the RME model reveals several key insights regarding its impact on students' numeracy literacy and cognitive styles. The RME model significantly improves students' numeracy literacy skills. Integrating local wisdom within this framework further enhances understanding of mathematical concepts, enabling students to solve problems more effectively. Regarding cognitive style, the study indicates that it does not significantly influence students' numeracy literacy. Additionally, there is no significant interaction between the RME learning model and cognitive styles in affecting numeracy literacy outcomes. These findings suggest that the effectiveness of the RME approach is independent of whether a student has an FI or FD cognitive style, demonstrating its broad applicability across diverse learner profiles.

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