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The Effectiveness of Malay Ethnomathematics-Based PMRI on the Numeracy Literacy of Junior High School Students

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Abstract

This study analysed the effectiveness of Malay ethnomathematics-based mathematics learning using the Indonesian Realistic Mathematics Education (PMRI) approach on the numeracy literacy of seventh-grade students at SMP Negeri 7 Kisaran. A quasi-experimental method with a nonequivalent control group design was employed. The participants were 64 students, consisting of an experimental class (n = 32) and a control class (n = 32). The experimental class learned through PMRI activities using Malay-Asahan cultural contexts, including traditional market transactions, songket motifs, local measurements, and daily community practices, whereas the control class received conventional instruction. The results showed that the two classes had comparable initial ability (pretest means of 52.3 and 51.8; Sig. = .803). After the

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treatment, the experimental class achieved a higher posttest mean score (81.4) than the control class (70.2). The independent samples t-test indicated a significant difference ($t = 5.42$; $df = 62$; Sig. $< .001$) with a large effect size (Cohen's $d = 1.36$). The experimental class N-gain (0.61) was also higher than the control class N-gain (0.38). These findings indicate that Malay ethnomathematics-based PMRI effectively improves students' numeracy literacy.

Keywords

Malay culture; ethnomathematics; numeracy literacy; PMRI; quasi-experiment

I. Introduction

Numeracy literacy is an essential competence that enables students to understand quantitative information, select mathematical strategies, interpret data, and make decisions in real-life contexts. In junior high school mathematics, numeracy literacy must be developed through contextual problems that require students to read situations, construct representations, perform calculations, and check the reasonableness of results (Ministry of Education and Culture, 2020; NCTM, 2000).

The need to strengthen numeracy literacy is increasingly urgent given that the mathematics achievement of Indonesian students in international assessments remains concerning. The PISA 2022 results placed Indonesia 70th out of 81 countries with an average mathematics score of 366, far below the OECD average of 472 (OECD, 2023). This data represents a phenomenon gap indicating that conventional learning models have not been optimal in developing students' contextual mathematical thinking. At the local level, the numeracy literacy achievement of seventh-grade students in North Sumatra based on the 2023 National Assessment falls into the "needs intervention" category, particularly in the domains of reasoning and data interpretation

(Ministry of Education, Culture, Research and Technology, 2023).

One approach that can bridge this need is learning based on local cultural ethnomathematics. Ethnomathematics views mathematical activity as growing within the social and cultural practices of communities, such as measuring, counting, comparing, estimating, arranging patterns, and making decisions (D'Ambrosio, 1985; Bishop, 1988; Rosa & Orey, 2011). Within the Malay-Asahan cultural context, traditional market transactions, songket motifs, betel trays, local measurements, and daily community activities can serve as sources of numeracy problems that are close to students' experiences.

So that cultural contexts do not merely decorate the problems, learning needs to be integrated with an approach that guides students to perform mathematisation. Indonesian Realistic Mathematics Education (PMRI) is relevant because it positions realistic contexts as the starting point of learning, giving students the opportunity to develop informal models, compare strategies, and construct mathematical concepts gradually (Freudenthal, 1991; Gravemeijer, 1994; Treffers, 1987; Zulkardi, 2002). Recent studies show that integrating PMRI with local cultural contexts consistently produces better improvements in mathematical ability than conventional learning (Maulyda et al., 2021; Widodo et al., 2022).

The integration of Malay cultural ethnomathematics and PMRI is also aligned with constructivist-sociocultural theory. Vygotsky (1978) emphasised that knowledge is formed through social interaction and cultural mediation, while culturally responsive teaching encourages the use of students' cultural experiences as a bridge for learning (Gay, 2018; Ladson-Billings, 2021).

The research gap in this study refers to the limited empirical evidence on the effect of Malay cultural ethnomathematics-based learning systematically integrated with

PMRI on the numeracy literacy of junior high school students. Previous studies have identified mathematical elements in Bugis (Pathuddin et al., 2021), Javanese (Supriadi et al., 2022), and Minangkabau (Febriyanti et al., 2022) cultures; however, research that specifically tests the effectiveness of the Malay-Asahan cultural context through a quasi-experimental design remains very limited. Existing studies are generally descriptive-exploratory and have not quantitatively measured their impact on numeracy literacy achievement.

The novelty of this study lies in three aspects. First, the Malay-Asahan cultural context is used as a source of numeracy problems that has never been empirically tested in a quasi-experimental setting. Second, this study integrates six PMRI learning stages into the ethnomathematics context systematically. Third, this study provides quantitative evidence with an effect size regarding the impact of the learning on the numeracy literacy of junior high school students in Asahan Regency, North Sumatra.

This study aims to analyse the effectiveness of Malay ethnomathematics-based mathematics learning with the PMRI approach on the numeracy literacy of seventh-grade students at SMP Negeri 7 Kisaran. The research hypothesis is that there is a significant difference in numeracy literacy between the experimental and control classes, with a higher improvement in the experimental class.

II. Method

This study used a quantitative approach with a quasi-experimental method. The design used was a nonequivalent control group design, which involves an experimental class and a control class without full random assignment of samples (Creswell & Creswell, 2018; Fraenkel et al., 2012). Both classes were given a pretest and posttest to observe changes in numeracy literacy after the treatment. The research design is presented in Table 1.

Table 1. Nonequivalent Control Group Research Design

Group	Pretest	Treatment	Posttest
Experimental	O1	X	O2
Control	O3	-	O4

Note: O1 and O3 = pretest; O2 and O4 = posttest; X = treatment using Malay ethnomathematics-based PMRI; (-) = conventional learning.

Place and Time of Research

The research was conducted at SMP Negeri 7 Kisaran, Asahan Regency, North Sumatra, in the even semester of the 2024/2025 academic year. The location was selected based on the suitability of students' characteristics with the Malay-Asahan cultural context used in the learning.

Population and Sample

The population of this study was all seventh-grade students at SMP Negeri 7 Kisaran. The sample was determined through purposive sampling, considering the equivalence of initial ability, the same grade level, learning schedules, and recommendations from the mathematics teacher. Two classes were selected as samples: one experimental class (n = 32) and one control class (n = 32), making a total of 64 research subjects.

Research Procedure

The research procedure was carried out in five stages: (1) preparation of learning tools, blueprints, essay items, instrument validation, and coordination with the teacher; (2) pretest for both classes; (3) implementation of the treatment—Malay ethnomathematics-based PMRI for the experimental class and conventional learning for the control class; (4) posttest; and (5) data analysis through descriptive statistics, prerequisite tests, hypothesis testing, N-gain, and effect size.

Learning Treatment

The treatment in the experimental class was carried out by integrating the Malay-Asahan cultural context into mathematical problems through the PMRI approach. The market transaction context was used to discuss ratio and proportion; songket motifs and carving patterns were used to introduce patterns and regularity; while local measurements were used to train the interpretation of numerical information. The learning stages are presented in Table 2.

Table 2. Malay Ethnomathematics-Based Learning Stages with the PMRI Approach

PMRI Stage	Implementation in Learning
Understanding the contextual problem	The teacher presents numeracy problems derived from Malay culture, such as traditional market transactions, songket motifs, carving patterns, or traditional games.
Developing an initial model or strategy	Students identify important information and create drawings, tables, schemes, or simple mathematical models based on the cultural context.
Solving the problem	Students use the chosen strategy to perform calculations, reasoning, modelling, and interpretation of results according to the demands of the numeracy items.
Comparing and discussing solutions	Students present their work, compare strategies between groups, respond, and improve their answers through class discussion.
Concluding mathematical concepts	The teacher guides students to draw concepts, procedures, or principles from the contextual problem solving toward more formal mathematics.
Reflecting on context and cultural values	The teacher and students reflect on the benefits of mathematical concepts in daily life and Malay cultural values: deliberation, cooperation, accuracy, and responsibility.

Research Instrument

The research instrument was a numeracy literacy test in the form of essay items covering four domains: numbers, geometry and measurement, patterns and algebra, and data and uncertainty. Scoring was carried out using an analytic rubric with a score range of 0–4 per indicator. Content validity was obtained through expert assessment, and only items meeting the eligibility criteria were used in the main study.

Data Analysis Technique

The data were analysed using descriptive and inferential statistics. The normality test used Kolmogorov-Smirnov and the homogeneity test used Levene. Hypothesis testing used an independent samples t-test at the 5% significance level. The effect size was analysed using Cohen's d (Cohen, 1988), and the improvement in ability was calculated through N-gain (Hake, 1998).

III. Result and Discussion

Data Description

The numeracy literacy data were obtained from the pretest and posttest of 64 seventh-grade students at SMP Negeri 7 Kisaran. The descriptive statistics are presented in Table 3.

Table 3. Descriptive Statistics of Numeracy Literacy

Class	n	Pretest M	SD Pre	Posttest M	SD Post	N-gain	Category
Experimental	32	52.3	8.1	81.4	7.2	0.61	Medium
Control	32	51.8	7.9	70.2	8.4	0.38	Medium

Table 3 shows that the pretest means of the experimental class (52.3) and the control class (51.8) were nearly identical, indicating comparable initial ability. After the treatment, the experimental class posttest mean increased to 81.4 while the control class reached 70.2 (a difference of 11.2 points). The experimental class N-gain (0.61) was higher than that of the control class (0.38), both in the medium category.

Prerequisite Tests

Normality and homogeneity tests were conducted before the hypothesis testing. The results are presented in Table 4.

Table 4. Normality and Homogeneity Test Results

Test	Data	Statistic	Sig.	Description
Normality K-S	Experimental posttest	0.112	0.156	Normal
Normality K-S	Control posttest	0.121	0.142	Normal
Homogeneity Levene	Exp–Control posttest	0.684	0.412	Homogeneous

Based on Table 4, the significance values of the normality test for both classes were > 0.05, so the data were normally distributed. The homogeneity test showed Sig. = 0.412 > 0.05, so the variances were homogeneous and the analysis could proceed with an independent samples t-test.

Test of Initial Ability Equivalence

The equivalence of initial ability was tested through pretest scores. The results are presented in Table 5.

Table 5. Pretest Equivalence Test Results

Data	Class	Mean	t value	df	Sig. (2-tailed)	Decision
Pretest	Experimental	52.3	0.25	62	0.803	Not significantly different
Pretest	Control	51.8				

The significance value of the pretest difference test was 0.803 > 0.05, indicating no significant difference in initial ability, so the posttest difference can be attributed to the learning treatment.

Hypothesis Test

The results of the independent samples t-test on the posttest scores are presented in Table 6.

Table 6. Posttest Hypothesis Test Results

Data	Class	Mean	t value	df	Sig.	Cohen d	Decision
Posttest	Experimental	81.4	5.42	62	< 0.001	1.36	H0 rejected
Posttest	Control	70.2					

The t value of 5.42 with Sig. < 0.001 led to the rejection of H0. There was a significant difference in numeracy literacy between the two classes. The Cohen's d value of 1.36 indicates a strong effect (Cohen, 1988).

The superiority of the experimental class was not merely due to the use of cultural context, but because the Malay cultural context functioned as an authentic source of mathematisation within the PMRI framework. In the traditional market transaction context, students did not only calculate procedurally but were required to identify relevant information, construct representations, select strategies, and interpret results in real situations. This process trains the four components of numeracy literacy in an integrated manner: understanding, modelling, calculation, and interpretation (OECD, 2023).

This effectiveness is explained through the principle of horizontal-vertical mathematisation in PMRI (Freudenthal, 1991; Gravemeijer, 1994). Horizontal mathematisation occurs when students use mathematical tools to organise real problems; vertical mathematisation occurs when students move from informal to formal representations. In the songket motif context, students observe patterns, create visual representations, find regularities, and then formulate generalisations in mathematical notation. This layered process is more effective in building conceptual understanding than procedural practice (Widodo et al., 2022; Rahayu et al., 2023).

From a sociocultural perspective, the effectiveness of PMRI is strengthened through the zone of proximal development (ZPD) mechanism in group discussion (Vygotsky, 1978). Contexts familiar to students reduce mathematics anxiety and increase cognitive engagement. Ladson-Billings (2021) shows that culturally responsive teaching not only increases motivation but also deepens concept processing. The meta-analysis by Maulyda et al. (2021) of 27 PMRI studies confirms that the integration of local contexts produces medium to large effect sizes, consistent with the Cohen's d = 1.36 finding in this study.

Compared with ethnomathematics studies on other cultures, these results show strong consistency. Pathuddin et al. (2021) found significant improvement in the Bugis cultural context. Febriyanti et al. (2022) reported an N-gain of 0.58 in the Minangkabau context, nearly identical to the finding of this study (0.61). Nata et al. (2023) examined the Malay Sumatra context and found that weaving motifs and customary transactions are effective vehicles for numeracy literacy. This consistency indicates that the mechanism of effectiveness lies in the use of meaningful contexts that activate deep mathematisation.

Practically, the superiority of the experimental class was also supported by the cultural value reflection stage in PMRI. When students reflect on the values of deliberation, cooperation, and accuracy in Malay tradition, there is a strengthening of mathematical disposition that encourages persistence in solving problems (Gay, 2018; Supriadi et al., 2022).

A limitation of this study is that the sample involved only two seventh-grade classes in one school, so generalisation must be done with caution. Further research is recommended to involve more schools, extend the duration of the treatment, and add variables such as learning motivation and mathematical disposition.

IV. Conclusion

Based on the research findings on 64 seventh-grade students at SMP Negeri 7 Kisaran, Malay ethnomathematics-based mathematics learning with the PMRI approach was proven effective in improving numeracy literacy, as shown by the initial equivalence (Sig. = 0.803), the significant posttest difference (t = 5.42; Sig. < 0.001), the strong effect size (Cohen's d = 1.36), and the experimental N-gain (0.61) > control (0.38).

This effectiveness occurred because the Malay-Asahan cultural context functioned as the starting point of horizontal-vertical mathematisation, activated the ZPD through meaningful discussion, and strengthened mathematical disposition through cultural value reflection. Thus, local culture becomes an authentic learning source rather than merely an illustration of problems.

Suggestion

Mathematics teachers are advised to develop numeracy problems based on specific local cultural contexts with clear mathematisation flows. Future researchers are advised to expand the sample to several schools, extend the treatment duration, and add affective variables to obtain a more comprehensive picture of effectiveness.

V. References

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