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# The Effectiveness of Website-Assisted Ethnomathematics-Based RME on Junior High School Students' Understanding of Mathematics

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**Abstract**

This study examines the effectiveness of Realistic Mathematics Education, also supported by a website based on ethnomathematics, on the understanding of math concepts among junior high school students. The research method used in this study is quantitative research with a pre-experimental design, one-group pretest-posttest. The sample in the study was 29 students, which was taken from the 8th-grade students of a junior high school in Yogyakarta, picked through cluster random sampling. This study's instruments were essay tests, which had been validated and proven reliable. The data from the research were analysed by descriptive and inferential statistics, where the inferential statistics included the Normality Shapiro-Wilk test and the One-Sample T-Test. The results indicated a significant improvement in students' understanding of math concepts after using RME through ethnomathematics-based website reach a significant change. This is evidenced by the posttest average value of 82.228, which is far more significant than the Minimum Mastery Criteria value of 75, and 79.31% of the students achieved and exceeded it. These results suggest that including local cultural contexts, batik motifs, and the Borobudur Temple structures in students' learning process can enhance the students' conceptual achievement level by strengthening the relationship with the learning process in their daily lives.

**Keywords**: ethnomathematics, mathematical concept understanding, realistic mathematics education, website

## INTRODUCTION

Mathematics forms an important aspect of contemporary life. Math is important in everyday life, aids in a variety of occupations, and belongs to our common knowledge. The employment competitiveness of mathematics and sciences is increasingly dependent on mathematics skills, particularly in technology, and thus, this is one of the main benefits of a dynamically evolving world (National Council of Teachers of Mathematics, 2000). Math should be taken advantage of by learning its concepts. The numerous real-world and working environments need a good understanding of math to solve practical problems (OECD, 2023b). Good mastery of math concepts can also help students relate ideas effectively, use the concepts in various contexts, and acquire new knowledge more easily. It also enhances memory, reduces errors in recalling procedures and enables students to evaluate and verify their thinking (Kilpatrick et al., 2001). According to Van de Walle et al., (2013) conceptual understanding is known to foster more connections in a student, helping blend new ideas with already known concepts. In the absence of these links, acquiring new information can feel lonely, and it becomes difficult to comprehend.

The Indonesian government recognises the importance of conceptual understanding in education, as reflected in the Merdeka Curriculum. This curriculum cuts down on the content and gives the students more time in order to internalise the concepts. This is the necessary depth to develop mathematical skills (Kemendikbudristek, 2024). Also, Decree No. 032/H/KR/2024 by the Education Standards, Curriculum, and Assessment Agency of the Ministry of Education, Culture, Research, and Technology states that one of the primary objectives of math education is to acquire both conceptual and procedural fluency. Thus, students are supposed to learn various mathematical concepts, such as facts, concepts, principles, operations, and relationships. They are expected to flexibly, accurately, efficiently, and appropriately apply these skills in solving mathematical problems. Nevertheless, the emergence of this objective is in sharp contrast with the realisation of Indonesia in the 2022 Programme of International Student Assessment (PISA). The Indonesian students in this evaluation by the Organization for Economic Co-operation and Development (OECD) have scored 69 out of 81, scoring 366 against an international average of 472 (OECD, 2023a). According to OECD (2023b, p.20) An individual can only solve PISA math problems after having a good conceptual background. These scores show that students do not have a conceptual learning of math, which makes the implementation of a math instruction based on the Merdeka Curriculum a necessity. This curriculum is founded on constructivist theory, which focuses on student-centred, relevant learning. Realistic Mathematics Education (RME) is one method that aligns with this philosophy.

RME perceives mathematics as a human activity. It focuses on significant uses in learning (Van den Heuvel-Panhuizen, 1996, p.14). In this style, students will actively form their knowledge in various contexts and models. They develop in different degrees of mathematization. This is achieved through teachers' contributions in facilitating discussions and assisting students in developing a mutual understanding based on their ideas (Gravemeijer, 1994, p.13). Mathematization is the process of conversion of non-mathematical or less mathematical phenomena into more systematic mathematical forms. It is a process emanating from reality. The selected realities have to be familiar and relevant to the students (Freudenthal, 2002). According to Sunzuma et al. (2021) Real-life situations need to be related to students' culture. Artefacts, arts, and traditional practices can be part of the cultural integration to be used in exploring mathematical concepts (Gerdes, 1999). Mathematics instruction which fits specific cultural contexts is called ethno-mathematics (Marsigit, 2016).

Many studies have shown that RME improves students' mathematical abilities. According to Palinussa et al. (2021), RME enhances students' mathematical reasoning and communication skills. Umbara & Nuraeni (2019) demonstrated that RME using Adobe Flash Professional CS6 can improve students' mathematical literacy. Muhtarom et al. (2019) showed that RME enhanced students' use of multiple representations. The support from Trisnawati et al. (2018) was seen in the improvement of mathematical communication skills. Anggraini & Fauzan (2020) noted that RME plays a role in developing mathematical problem-solving skills. Novika et al. (2022) stated that RME effectively improves mathematical connections. Zetriuslita et al. (2025) reported how the RME approach can increase students' learning outcomes. These findings further demonstrate that RME can improve several aspects of students' mathematical competence.

Application of information and communication technologies is, therefore, a crucial component in providing interactive and engaging learning relevant for the 21st-century education processes as suggested by Zhao (2010). Technology is also a key component in the Indonesian curriculum whereby learning processes are being increasingly centered on the storage, processing, and access of information toward the formation of new knowledge and enhancement in student learning as stated by (Kemendikbudristek, 2024). Web-based learning is one of the ways to introduce technology into education. E-learning, as it is commonly known, delivers instructional materials online.

Website-based learning offers several advantages. These include: (1) the ability to connect different resources in various formats, (2) efficiency in delivering instructional materials, (3) high accessibility from different locations at any time, (4) the potential to expand access for part-time students, adult learners, and working students, (5) encouragement of more independent and active learning, and (6) the provision of functional supplementary materials for traditional programs (Wasim et al., 2014). Additionally, Nuranggraeni & Jusra (2023) found that website-based learning using Google Sites improves students' problem-solving skills in mathematics. Pradana et al. (2024) suggest that instruction based on Google Sites can help develop critical and creative thinking in elementary school students.

Although many studies have shown that RME effectively improves students' math skills (Palinussa et al., 2021; Umbara & Nuraeni, 2019; Muhtarom et al., 2019; Novika et al., 2022), the potential integration with cultural contexts and digital technology has not been deeply examined. Research combining RME with ethnomathematics has occurred chiefly in traditional learning environments without technological support (Jariyah et al., 2025; Nuraina et al., 2021). On the other hand, studies that connect RME with technology primarily focus on the use of digital media, while ignoring cultural elements (Nurhayati et al., 2023; Umbara & Nuraeni, 2019). To fill this research gap, this study examines the effectiveness of web-assisted ethnomathematics-based RME in improving junior high school students' understanding of math concepts. The key research question is: Does web-assisted ethnomathematics-based RME effectively improve students' understanding of math concepts?

## METHOD

The research employed a one-group, pretest-posttest design, a quantitative design. The design was selected to obtain a clear picture of students' knowledge of mathematical concepts before and after the treatment. It was to measure the improvement of their abilities after the learning process. Consequently, we evaluated the effectiveness of learning relative to the Minimum Mastery Criteria and improvements in students' abilities by comparing their initial performance with their outcomes after the treatment.

The research was conducted in a state-owned junior high school in Yogyakarta between October and November 2024. A cluster random sampling technique was used to select 29 eighth-grade students. Four experts reviewed the assessment tool for students' conceptual understanding in mathematics. They used Aiken's V index, which ranges from 1 to 5, and agreed it was valid after considering their feedback. Cronbach's Alpha was used to test the reliability of the pretest and posttest tools. Table 1 illustrates the reliability coefficients.

Table 1. Instrument Reliability Results

| Reliability | Statistic | Reliability Coefficient | Decision |
|---|---|---|---|
| Pretest | 0.655212 | 0.65 | Reliable |
| Posttest | 0.674643 | 0.65 | Reliable |

This study involved several research procedures that included selecting a class, a pretest to identify students' prior knowledge, a learning intervention, Realistic Mathematics Education (RME), which was an ethnomathematics-based, website-assisted approach, and a posttest procedure to identify students' understanding of mathematical concepts after a learning process involving the intervention of RME. This study also involved the use of elements of local cultures, such as the Borobudur Temple and the Batik of Yogyakarta designs, as a learning background for learning numerical patterns. This was done through an interactive learning system supported by a website designed by the research team to learn mathematics and include elements of a local culture in learning math.

The website-assisted ethnomathematics-based Realistic Mathematics Education (RME) occurred over three sessions, with a website in each session. During the first session, Borobudur Temple represented patterns of numbers in reference to squares and triangles. The second lesson involved batik patterns (Grompol, Nitik, and Sekar Jeram) to learn about the patterns of rectangular numbers and ten and twelve-digit numbers. The third lesson applied Parang and Kawung batik patterns to aid students in learning the arithmetic sequences and series. Table 2 can be used to recapitulate how cultural artifacts are integrated into learning.

Table 2. Local Cultural Artifacts Used in Learning Numerical Patterns

| No. | Cultural Artifact | Mathematical Aspect Explored |
|---|---|---|
| 1 | Borobudur Temple  | The stupa holes of Borobudur Temple can help students understand square and triangular number patterns, as illustrated below.<br>Square Number Pattern <br>Triangular Number Pattern  |
| 2 | Batik Grompol  | Rectangular Number Pattern<br>The Grompol batik motif is utilized to construct a rectangular number pattern through the following motif arrangement.  |
| 3 | Batik Nitik  | Triangular Number Pattern<br>The Nitik batik motif is used to form a triangular pattern through a specific arrangement of motifs.  |
| 4 | Batik Sekar Jeram  | Even Number Pattern<br>The Sekar Jeram batik motif is used to introduce and identify even-number patterns through a systematic arrangement of the motif.  |

| | | |
|---|---|---|
| 5 | Combined Parang and Kawung Batik Motifs  | Arithmetic Sequences and Series<br>A combination of Parang and Kawung batik motifs is used as a contextual medium to help students discover the formulas for arithmetic sequences and series. This is achieved by identifying the pattern of motif occurrences within a given sequence. |

The techniques used to analyze the data were both descriptive and inferential. The descriptive analysis provided a clear picture of students' knowledge of mathematical concepts before and after the treatment. The data provided consists of the mean, standard deviation, maximum, and minimum scores. Then, N-Gain analysis was conducted to determine the extent to which students became more conceptually understandable from the pretest to the posttest. The level of improvement in the N-Gain score is based on the classification adapted from Hake (1998) criteria, as presented in Table 3.

Table 3. Interpretation Criteria for n-Gain Scores

| **n-Gain Score** | **Interpretation** |
|---|---|
| $g \geq 0.7$ | High |
| $0.3 \leq g < 0.7$ | Moderate |
| $g < 0.3$ | Low |

Inferential analysis was used to test the hypotheses and draw conclusions from the empirical data. The RME-based learning intervention, using ethnomathematics and a website, was found to be effective in improving students' conceptual knowledge. This assessment was successful, given the Learning Achievement Criteria used in the school where it was conducted, which has adopted the Merdeka Curriculum. Such a measure of the effectiveness of the learning was used on the basis of the following criteria:

1. The average score of students ≥ Minimum Mastery Criterion (75)
2. At least 75% of students achieved or exceeded the Minimum Mastery Criterion score

The statistical tests used in this study included normality testing and effectiveness testing. The normality test used the Shapiro-Wilk test to assess whether the data were normally distributed. After that, the one-sample t-test was used to assess learning effectiveness.

One Sample t-test Hypotheses:

- $H_0$: The mean posttest score of conceptual understanding < Minimum Mastery Criterion (75)
- $H_1$: The mean posttest score of conceptual understanding ≥ Minimum Mastery Criterion (75)

## RESULTS

### Descriptive Data

The results of this study show that students' understanding of mathematical concepts improved after using website-assisted ethnomathematics-based Realistic Mathematics Education (RME). Table 4 summarizes students' mastery of mathematical concepts.

Table 4. Descriptive Statistics of Students' Mathematical Conceptual Understanding

| Description | Experimental Class Scores | |
|---|---|---|
| | Pretest | Posttest |
| Number of Students | 29 | 29 |
| Mean Score | 50.313 | 82.228 |
| Standard Deviation | 19.996 | 11.739 |
| Minimum Score | 13.636 | 57.692 |
| Maximum Score | 81.818 | 100 |

**The Improvement of Students' Conceptual Understanding**

An N-Gain analysis measured the extent to which students' understanding improved after participating in ethnomathematics-based learning. This learning used the RME approach and was supported by a website. The analysis aimed to find out how much students improved from the pretest to the posttest.

Table 5. n-Gain Calculation Results

| n-Gain Score | Interpretation |
|---|---|
| 0.602 | Moderate |

Based on Table 5, the N-Gain score was 0.602. This score falls within the medium range according to Hake (1998) classification. This finding shows that using website-assisted ethnomathematics-based RME led to a moderate improvement in students' understanding of mathematical concepts.

The data are presented in Figure 1 to further examine the detailed improvement in scores for each indicator between the pretest and posttest.

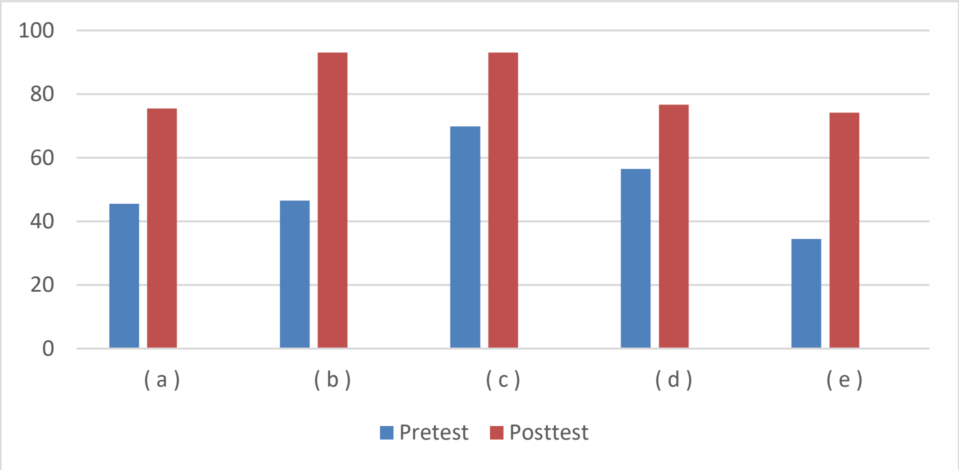



Figure 1. Score Improvement for Each Indicator

The graph in Figure 1 compares pretest and posttest scores for each indicator of students' understanding of mathematics. In the case of indicator (a), which was used to determine the capacity to recall math concepts that were previously acquired, the average score increased to 75.43 in the posttest compared to 45.47 in the pretest. This is a gain of 29.96 points. The most improved indicator (b) was the classification of objects with respect to math concepts, which improved from 46.55 to 93.10 —a difference of 46.55 points. In the case of indicator (c), which examines the capacity to provide examples and non-examples of a concept, the score increased by an increment of 23.28 points; in the pretest, it was 69.83, with an increase in the posttest, it was 93.10. In the meantime, the indicator (d), related to using and applying specific procedures, showed the smallest increase, rising from 56.47 to 76.72 — a gain of 20.26 points.. Lastly, indicator (e), which measures the use of concepts or methods of solving problems in math problems, improved by a significant margin of 39.66 points, with the pretest score of 34.48 improving to the posttest score of 74.14.

**Data Analysis**

Before conducting hypothesis testing, it is important to perform a normality test first. This test is necessary because you can only carry out hypothesis testing if the sample comes from a normally distributed population. In this study, the Shapiro-Wilk normality test was used at the 0.05 significance level. The results of the normality test are shown in Table 6.

Table 6. Normality Test Results

| Experimental Class | w | p-value |
|---|---|---|
| Post-test mathematical concept understanding | 0.955 | 0.239 |

Based on Table 6, the normality test yielded a p-value of 0.239. Since $p > 0.05$, the null hypothesis ($H_0$) is accepted. Therefore, the posttest scores are normally distributed.

**The Effectiveness of Ethnomathematics-Based RME Assisted by a Website**

Table 7 shows the percentage of students who achieved mastery according to the Minimum Mastery Criteria. It demonstrates how many students met the standard and indicates the success of the teaching method used.

Table 7. Percentage of Students' Posttest Scores

| Minimum Mastery Criterion | Number of Students | Percentage |
|---|---|---|
| ≥ 75 | 23 | 79.31 |
| < 75 | 6 | 20.69 |

To assess the effectiveness of the ethnomathematics-based RME supported by a website, we analysed data using a One-Sample t-test. This test aimed to determine whether the average posttest score was significantly higher than the Minimum Mastery Criterion score of 75. This would give us insight into the effectiveness of the learning intervention.

Table 8. Hypothesis Testing Results

| One Sample T-Test | t | df | p-value |
|---|---|---|---|
| Post-test mathematical concept understanding | 3.316 | 28 | 0.003 |

From Table 8, it is found that in the hypothesis test, the calculated p-value is 0.003, which is less than 0.05. Therefore, it leads to the rejection of the null hypothesis (H0). Thus, it is concluded that students' average score of understanding mathematical concepts after the intervention is significantly higher than the Minimum Mastery Criterion of 75 points. This indicates that the proposed website-assisted, ethnomathematics-based RME is effective in improving students' understanding of mathematical concepts.

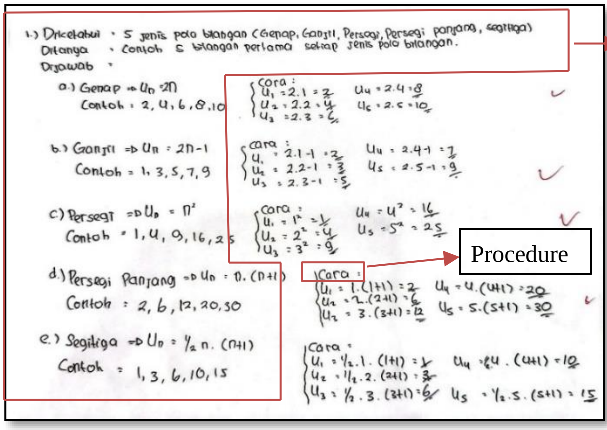
## DISCUSSION

The implementation of ethnomathematics-realistic mathematics education supported by a website was a huge success, as it was implemented at a rate of 98.6%. In terms of learning, it involved real-world challenges that aimed at securing understanding, learning by exploring and discussing, finding out, and concluding through sharing findings in learning activities. There was a marked improvement in students' familiarity with mathematical concepts. Initially, the average standard of students was 50.313. After implementation, it rose to 82.228.

In addition, N-Gain analysis also produced a score of 0.602, which was classified as medium based on the criteria by Hake (1998). This score was calculated through a comparison of pretest and posttest data. This data proved that students' mathematics ability was enhanced after a learning intervention. This data indicates that a web-based, ethnomathematics-based Realistic Mathematics Education (RME) was beneficial in improving students' understanding of math concepts because of an N-Gain value classified as medium, indicating that the learning intervention positively influenced students' learning capacity in math concepts.

Together with this overall progress, all the indicators that could measure students' understanding of a concept showed positive changes. Among those that showed a positive improvement was in the ability to classify objects based on mathematics concepts, where the average score increased by 46.55 points. This improvement signified an enormous expansion in students' understanding of mathematics concepts.

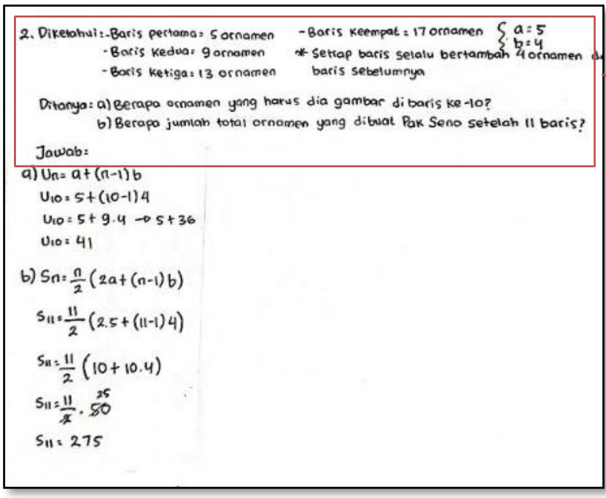
The standard for instructional effectiveness is defined as at least 75% of students scoring above the Minimum Mastery Criterion, which is set at 75. The results showed that 79.31% of students scored above this threshold. In addition, a one-sample t-test indicated that the average score on the posttest for mathematical conceptual understanding was equal to or greater than the Minimum Mastery Criterion score of 75. These results confirm that the web-assisted, ethnomathematics-based RME approach effectively improves students' conceptual understanding. Below, you will find an example of students' posttest responses that show their understanding of mathematics.




Given five types of numerical patterns: Even, Odd, Square, Rectangular, and Triangular.
Question: Provide examples of the first five numbers from each type of numerical pattern.
Answer:
a. Even number pattern
Examples: 2, 4, 6, 8, 10 ⟹ $U_n = 2n$
b. Odd number pattern
Examples: 1, 3, 5, 7, 9 ⟹ $U_n = 2n-1$
c. Square number pattern
Examples: 1, 4, 9, 16, 25 ⟹ $U_n = n^2$
d. Rectangular number pattern
Examples: 2, 6, 12, 20, 30 ⟹ $U_n = n(n+1)$
e. Triangular number pattern
Examples: 1, 3, 6, 10, 15 ⟹ $U_n = \frac{1}{2}n \cdot (n+1)$

Figure 2. Excerpt of Student Responses on the Posttest.

Based on Figure 2, students showed their understanding by giving examples and non-examples. They also classified objects according to numerical patterns such as even and odd numbers, square numbers, rectangular numbers, and triangular numbers. Most students solved the problems using the correct formula patterns. This shows they understand the key concepts related to each number pattern.



Given:
- Row 1 = 5 ornaments
- Row 2 = 9 ornaments
- Row 3 = 13 ornaments
- Row 4 = 17 ornaments
- Each row contains 4 more ornaments than the previous one.

Question:
a) How many ornaments should be drawn in the 10th row?
b) What is the total number of ornaments Mr. Seno will have drawn after 11 rows?

Answer:

Figure 3. Excerpt of Student Responses on the Posttest.

Based on Figure 3, students successfully identified the next term in a number sequence using arithmetic progression. They applied arithmetic series formulas to solve problems. These findings indicate that the students recognized patterns in numbers and correctly applied the appropriate mathematical processes.

The RME (Realistic Mathematics Education) approach allows students to use real-life situations to develop an abstraction of mathematical concepts. According to Freudenthal (2002), mathematics is learned through a process known as mathematization, which is divided into two phases: horizontal and vertical mathematization. Horizontal mathematization involves mathematizing real-life problems or issues using symbols or mathematical models. On the other hand, vertical mathematization focuses on interactions within a mathematics system that include developing methods of solutions, relationships of ideas, and creating mathematical rules. From research findings, it is clear that Freudenthal (2002) opinions are supported, in that RME facilitates students in performing both phases of mathematization. From previous research studies, it is clear that it is an effective learning strategy in increasing students' knowledge of mathematics in their minds. Jeheman et al. (2019) opine that RME has a positive effect on understanding students' perceptions of mathematics concepts. A study by Mahendra et al. (2017) found that students' understanding of mathematics was greatly enhanced through RME. Similarly, in a research study carried out by Lestari & Surya (2017), it was clear that it was highly effective in increasing students' understanding of mathematics concepts.

This study affirmed mathematization by embracing students' local cultures in learning mathematics in an abstract form. Local Batik designs that embrace cultural elements include Batik Grompol, Batik Nitik, Batik Sekar Jeram, Batik Parang, Batik Kawung, as well as Borobudur Temple architecture. These designs of cultures act as real aiding models that make it easy for students to learn mathematical ideas through real events, thereby improving understanding in math. This agrees with Priyatna & Marsigit (2024), proving that involving Yogyakarta Palace cultural artifacts was beneficial in improving the understanding of mathematical ideas by students. On a similar note, Jabali et al. 2020) highlighted that learning through cultures is beneficial in improving students' ability to understand mathematical concepts. On a similar note, Pratama & Yelken (2024) have noted a positive effect of involving cultures in improving students' math literacy skills. Umbara et al. (2023) have also proved that Sundanese Ethnomathematics has a positive influence on improving math literacy in a positive manner. In fact, it is clear that involving learning in math through cultures is an apt addition in countries such as Indonesia, which have a diverse background in terms of cultures, as described in (Maulina et al., 2023).

The website was an interactive learning tool. It contained videos on artifacts of Borobudur Temple, images of batik in Yogyakarta, worksheets on ethnomathematics learning using RME, and quizzes. Through this online learning platform, students have easy access to learning materials. Students are also capable of interacting with online materials and acquiring their own and socialized knowledge. During the learning process, students filled out a worksheet in the online platform. This involved students in learning activities, boosted learning outcomes, and supported students in learning through an interactive learning process. This study's findings are well related to those of Albab et al. (2021), who found that technology-assisted learning increased the involvement of students in learning. Research findings of a study by Komar et al. (2022) showed that the learning achievements of students increased in technology-assisted learning of mathematics. Similarly, the Ministry of Education, Culture, Research, and Technology, Kemendikbudristek (2024) mentioned that the use of technology increased learning quality. In addition, the use of websites as learning tools in math learning was also capable of supporting students in gaining an understanding of the materials appropriately. This was because findings of research by Buraidah & Rahmawati (2023) showed that learning through Google Sites increased students' conception. Similarly, findings of a research study by Samo et al. (2023) affirmed that online learning of mathematics produced positive impacts on learning achievements. This study's findings also provided an explanation that the use of technology facilitates active learning and is consistent with constructivist values of the Merdeka Curriculum, which allows students to build their knowledge.

While implementing the web-based ethnomathematics-based RME strategy in the classroom, difficulties arose due to students' varying technological knowledge. At times, it became challenging for them to retrieve academic materials from the website. Nonetheless, the strategy aligned with the objectives of the Merdeka Curriculum because it developed students' conceptual knowledge. As stated in (Julianto et al., 2021), technology integration with ethnomathematics can effectively develop students' logical thinking skills. By associating mathematical concepts with their cultural knowledge or experiences, students form a tighter cognitive linkage to facilitate their understanding of mathematical concepts. As confirmed in (Van de Walle et al., 2013) learning associated with ideas quickens students' pace in mastering new mathematical concepts.

The integration of ethnomathematics-based RME with the online site focused on Yogyakarta cultural themes like batik art and objects from Borobudur Temple is certainly an innovative alternative not often explored in realistic mathematical education. This alternative makes a World of Difference in designing or contributing to one's knowledge or understanding with technology related to mathematical education.

## CONCLUSION

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## DECLARATIONS

| | | |
|---|---|---|
| Author Contribution | : | Author 1: Conceptualization, Writing - Original Draft, Editing and Visualization;<br>Author 2: Review & Editing;<br>Author 3: Review & Methodology;<br>(https://www.elsevier.com/authors/policies-and-guidelines/credit-author-statement) |
| Funding Statement | : | The author received no financial support for the research, authorship, and/or publication of this article. |
| Conflict of Interest | : | The authors declare no conflict of interest. |
| Additional Information | : | Additional information is available for this paper. |

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