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Fort Marlborough Ethnomathematics-Based Learning Handouts: Enhancing High School Students' Mathematical Literacy Skills

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Abstract: This study aims to develop a valid, practical, and effective learning handout based on the ethnomathematics of Fort Marlborough, Bengkulu, to enhance students' mathematical literacy. The research method used is research and development. The development model used is a formative evaluation with stages including self-evaluation, expert review, face-to-face sessions, small-group sessions, and field testing. This study involved test subjects of grade X high school students in Bengkulu City, Indonesia. The test subjects in this study were divided into several stages of the research. This study involved four experts (mathematics lecturers) from different universities. The one-to-one test stage involved six high school students (high, medium, and low abilities). The limited-scale test stage involved 24 grade X high school students, and the large-scale implementation with 43 subjects. Data collection techniques used were observation, questionnaires, and tests. Data analysis was carried out quantitatively and qualitatively. Quantitative and qualitative analyses examined the validity, practicality, and effectiveness of the mathematical literacy test. Analysis was also carried out descriptively on the results of suggestions from expert assessments of research products. The results of the study showed that: 1) the trigonometry learning handout based on the ethnomathematics of Fort Malborough Bengkulu that was developed meets the valid criteria based on the assessment of material, construction, and language by experts, with an average score of 0.63 (valid). 2) The trigonometry learning handout meets the practical criteria based on student assessment, with an average response score of 3.43 (very practical). The trigonometry learning handout has the potential to enhance high school students' mathematical literacy skills. In developing teaching materials using context, it is necessary to choose the proper context, and the illustration must be clear and easy to understand, in accordance with the material.

Keywords: learning handout, ethnomathematics, Fort Marlborough, mathematical literacy skills.

▪ INTRODUCTION

The implementation of the independent curriculum in Indonesia is the government's effort to improve the quality of educational outcomes. One objective of its implementation is to develop learners' independence, critical reasoning skills, and creativity (Kemendikbud, 2022). The government also continues to monitor student learning outcomes in the classroom by implementing minimum competency assessments (in Indonesia, AKM). Indicators of learning outcomes align with international standards, including the PISA survey, which focuses on mathematical literacy. Literacy is one of the objectives of the independent curriculum implementation. Mathematical literacy is an AKM test objective (Wijaya, Dewayani, Effendi, & Gunawan, 2021); a demand of 21st-century skills (Drew, 2012); international education achievement indicators (Holenstein, Bruckmaier, & Grob, 2021); Independent curriculum objectives in Indonesia (Kemendikbud, 2022); and skills that students must master in each region (Ahyan, Turmudi, & Juandi, 2021). Mathematical literacy is the ability to identify, interpret,

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formulate, solve problems, and communicate mathematical concepts in various daily contexts (OECD, 2013; Geiger, Goos, & Forgasz, 2015). Literacy is also defined as the knowledge and the ability to apply it in real life, involving mathematics (Sumirattana, Makanong, & Thipkong, 2017).

Mathematical literacy skills are important to develop in mathematics learning as the ultimate goal in classroom learning. Previous researchers have stated the importance of mathematical literacy skills. Literacy skills will affect students' ability to solve everyday problems (Geiger et al., 2015). Literacy can also help students recognize the benefits of mathematics in everyday life (OECD, 2017), enabling them to solve complex problems (Jailani, Retnawati, Wulandari, & Djidu, 2020). However, students' literacy achievement in mathematics remains low. Survey results, both international and national, show that students' performance in Indonesia remains low. The survey shows the importance of emphasising the skills students must master as outcomes of classroom learning, including mathematical literacy. According to the international PISA survey, Indonesian students' achievement remains below the international average (OECD, 2019; Fathani, 2016; Zulkardi et al., 2020). Indonesia's 2018 PISA results are in the low-performing quadrant (Pusmendik-Kemendikbud, 2019). National data shows that learning outcomes in Indonesia still need improvement. Data from the AKM results in 2022 show that students' achievement at the minimum competency level for numeracy skills is below 50% (Pusmendik-Kemendikbud, 2022). Several studies have also shown that certain mathematical content is difficult for students to grasp. Research by Susanto, Fransiska, and Susanta (2023) showed that geometry was one of the subjects with the lowest mastery, with student achievement at only 33.15%. Trigonometry, in particular, involves many contextual problems that students find difficult to grasp.

Low achievement in mathematics learning outcomes, especially in reasoning and thinking skills, including literacy, occurs at every school level. Empirical data show that students' ability to solve high-level thinking problems is, on average, low (Susanto & Retnawati, 2016). Students' abilities in reasoning questions are, on average, in the low category (Susanta, Susanto, & Maizora, 2021). In addition, students from rural schools consistently have low literacy skills during PISA implementation (Direktoratdikdas, 2022). Therefore, it needs special emphasis in the classroom to develop students' mathematical literacy. The low level of mathematical literacy in schools is partly influenced by the classroom application of learning models (Jehlička & Rejsek, 2018). The use of classroom teaching materials designed to develop students' mathematical literacy skills is one solution to the problem of low student literacy achievement. However, reality shows that there are still limited learning resources or teacher-designed teaching materials to support students' literacy skills, even though this is important. This gap will affect the achievement of learning outcomes.

In addition, developing students' mathematical literacy skills is not the same across materials, as the characteristics of mathematical materials do not require special analysis to select appropriate teaching materials. One of the materials at the secondary school level is trigonometry, which is used in problems involving measurements (Mall & Grant, 2016). Learning trigonometry will optimise students' abilities to solve problems involving reasoning and proof (Tutak, 2017). Thus, teaching materials need to be specifically designed so that students can use their abilities to measure and solve the problems given. Some studies note that trigonometry is difficult because some of its material is abstract

(Mensah, 2017). Teaching materials that can bridge the abstract nature of trigonometry to make it concrete are required. One approach to providing teaching materials to support students' literacy in trigonometry is the use of ethnomathematics with a local context. The use of ethnomathematics in the local context is believed to help students develop mathematical models to solve given problems.

Many studies have examined the effectiveness of teaching materials that draw on the ethnomathematics of local or cultural contexts in improving students' thinking skills. Emphasising contextual issues, especially local contexts, is closely related to facilitating students' literacy skills in important learning linked to open materials (Susanta, Sumardi, & Zulkardi, 2022). This opinion shows that literacy activities can be linked to the local context. One way to bridge culture and mathematics is to explore mathematical concepts and principles grounded in ethnomathematics (Wahyuni, Aji, Tias, & Sani, 2013). According to Stroyer, Nainggolan, & Hutabarat (2018), problems related to culture will inevitably surround the process of learning mathematics, including all forms of mathematics. Therefore, linking with the cultural context needs to be applied in teaching materials. In addition, the use of contexts close to students can make it easier for students to recognize and understand problems before solving them (Zulkardi, 2013) and to train critical thinking, creativity, and problem-solving skills (Kadir & Masi, 2014). The use of context in mathematics learning can relate to everyday life, helping students understand (Zulkardi & Kohar, 2018).

Several studies show that learning in contexts, such as culture, ethnomathematics, and regional contexts, can improve students' skills. The results show that the use of ethnomathematics content in classroom learning is effective in improving students' abilities (Sarwoedi, Marinka, Febriani, & Wirne, 2018). Other research also shows that using local context can enhance students' mathematical literacy (Susanta, Sumardi, Susanto, & Retnawati, 2023). Presenting culture as a contextual problem can foster students' abilities (Febrian, Wardono, & Supriyono, 2013).

Based on findings from several studies, it is necessary to examine learning resources by exploring ethnomathematics in Fort Marlborough, Bengkulu. Mathematical concepts in Fort Marlborough, Bengkulu, can serve as a learning resource for senior high school students. The context of Fort Marlborough, Bengkulu, is more familiar to students, especially high school students in Bengkulu City, which is likely to make it easier for students to perform mathematical modeling to solve problems. This emphasis on the fort's context is relevant to the application of trigonometric concepts, such as elevation angles, ratios, sines, and cosines. For example, measuring the height of a gate can be done using trigonometric concepts. Therefore, we conducted research by exploring mathematical concepts in the ethnomathematics of Fort Marlborough as a source of teaching material to support trigonometry literacy skills for high school students. The focus of this research question is as follows.

- How valid is the ethnomathematics-based learning handout in the context of Fort Marlborough to support high school students' mathematical literacy skills?
- How practical is the ethnomathematics-based learning handout in the context of Fort Marlborough to support high school students' mathematical literacy skills?
- How effective is the ethnomathematics-based learning handout in the context of Fort Marlborough in terms of high school students' mathematical literacy skills?

▪ METHOD

Participants

Participants in this study were tenth-grade students of public senior high schools in Bengkulu City. The study population comprised all tenth-grade students from 10 public senior high schools in Bengkulu City. The sample of trial subjects was tenth-grade students from public senior high schools (SMAN) 1 and 4 in Bengkulu City. The selection was carried out using a purposive sampling technique, namely, based on research needs and the researcher's distance. The choice of these schools was also based on initial observations that indicated the need to develop teaching materials to address learning problems. The sample of trial subjects was selected using a simple random sampling technique, namely by selecting randomly from all existing classes from the selected schools. This can be done because each class is not grouped by academic level. The trial subjects were selected based on each stage of the study. In the one-to-one test stage, six students were selected (school 1, n = 3; school 2, n = 3). Students were selected based on different abilities (high, medium, and low) from academic assessments. Participants in the implementation stage were limited to 12 students chosen from class XC SMAN 1 and XA SMAN 4. Meanwhile, a large-scale implementation (effectiveness test) was conducted with 43 students (school 1, n=24; school 2, n=19).

Research Design and Procedures

The research method carried out is research and development. This research uses a formative evaluation development model (Tessmer, 2013). This model was chosen because it refers to the research objective, namely, developing teaching materials in the form of Fort Marlborough Bengkulu ethnomathematics-based learning handouts that are valid, practical, and have potential impact. The research was conducted for two months. Therefore, the testing needs to be carried out in stages, starting from self-evaluation by researchers to broad assessment by users. The research stages of the formative evaluation model consist of (a) self-evaluation, (b) prototyping (expert reviews, one-to-one, and small group), and (c) field. In the self-evaluation stage, the suitability between the material and the context of Fort Malborough Bengkulu was analysed. This stage also analyses and rechecks the prepared product draft, reviewing its materials and construction. Furthermore, researchers assess the appropriateness of the context used for the material presented. The self-evaluation was also based on a needs analysis for teachers and on exploration activities for Fort Malborough.

The next stage is prototyping, where the draft learning handout is evaluated by experts in the relevant field to assess its validity and by one-on-one testers to assess its readability. The product is then tested with a small group of students to assess its ease of use. During field testing, classroom instruction used the learning handout to assess the product's effectiveness.

Instruments

Data were collected through non-test and test instruments. The non-test instruments were a validation sheet used to assess validity and a practicality sheet used to evaluate the practicality of product use. The validation sheet was designed with answer choices, SK = Very Poor (1), K = Poor (2), B = Good (3), and SB = Very Good (4). The validation sheet was compiled based on the indicators in the following table.

Table 1. Product validation sheet indicators

No	Aspect	indicators	Number
1	Eligibility of content	Material suitability	1-3
		Accuracy of material	4-9
2	Feasibility of Presentation	Presentation Techniques	1-4
		Sequence of Presentation	5-6
3	Language eligibility	Straightforwardness	1-3
		Communicative	4-5
		Conformity of method	6-9
4	Use of the Ethnomathematics	Contexts	1-3

Another non-test instrument is the practicality sheet. This instrument consists of 12 items with a rating scale: 1 = poor; 2 = adequate; 3 = good; 4 = very good. Practicality is measured from several theoretical aspects, namely: 1) Appearance images, colors, and layout (n=3); use of font type and size on products (n=4); use of language in the product (n=3); use of the context of fort malborough (n=3); and presentation of material and exercises (n=2).

The test instrument was a trigonometry-based mathematical literacy test. The test was designed in a descriptive format consisting of five questions. The test aimed to measure effectiveness after product use. The test instrument in this study measured students' trigonometry-related mathematical literacy skills using five questions. The questions were developed using mathematical literacy indicators for trigonometry. The indicators of the test instrument in this study were: 1) understanding context, 2) modeling and representation, 3) problem solving, 4) reasoning and argumentation, and 5) reflection and communication.

To maintain the validity of the research data, the data collection instruments were first analyzed. The research instrument for measuring product effectiveness is a trigonometric literacy test comprising five questions. Experts assess the questions to determine their suitability in terms of construct, content, and language. In addition, the questions were analyzed empirically to assess reliability and estimate the standard error of measurement (SEM). Based on the expert assessment, the questions are valid across the construct, content, and language aspects. Reliability analysis using Cronbach's alpha was conducted based on empirical tests with 24 grade XI students. The selection of 11th-grade students for an empirical test of the research instrument was because they having studied the material, allowing the quality of the questions to be analyzed. The analysis yielded a Cronbach's alpha of 0.74, indicating reliability. Meanwhile, the SEM test results obtained a value of 0.023. This shows that the questions for testing the effectiveness of teaching materials are suitable for use. We present one of the mathematical literacy test instruments in Figure 1 below.

Data Analysis

The research data were analyzed quantitative and qualitatively to describe the description of the characteristics of the learning handouts developed. Characteristics are reviewed for validity, practicality, and potential impact on students' literacy abilities. The validity of research products was assessed using the Aiken index. Products are valid if

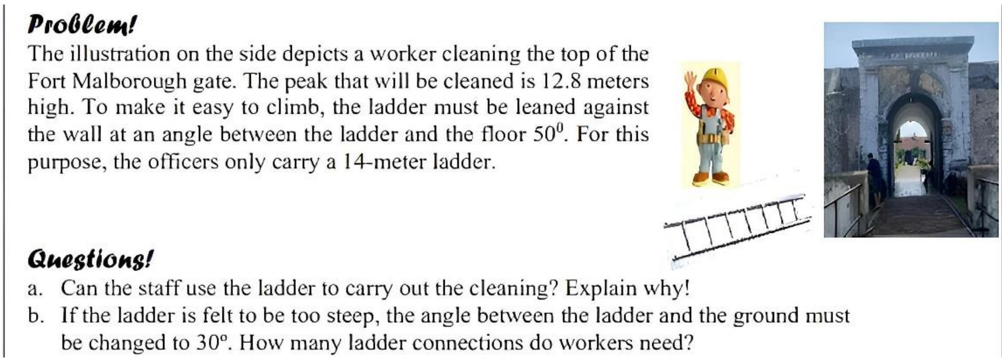


Figure 1. Examples of mathematical literacy tests (in english)

the Aiken index is more than 0.5 (Aiken, 1980). Practicality data were analyzed based on ease-of-use assessments from small-scale trials. Practicality score analysis based on an assessment questionnaire ranging from 1-4 with 10 statement items. The practicality criteria for the practicality test are: 1.00-1.80 (not practical), 1.81-2.60 (poor), 2.61-3.40 (practical), and 3.41-4.00 (very practical).

The potential impact was analyzed based on student questionnaire responses and trigonometry test scores. Analysis of product effectiveness was also carried out using descriptive statistics to describe students' trigonometric literacy skills at levels 0-33 (low), 34-66 (medium), and 67-100 (high). Meanwhile, the categories of students' abilities in solving each problem are as follows.

Table 2. Achievement criteria for each indicator

Intervals	Criteria
$0 < P \leq 30\ \%$	Low
$30\% < P \leq 60\ \%$	Medium
$60\% < P \leq 100\ \%$	High

As a criterion for product effectiveness in this study, we used students' mathematical literacy levels in solving trigonometry problems. A product is considered effective if the average student's mathematical literacy falls within the medium to high criteria.

▪ RESULT AND DISSCUSSION

Self-evaluation Phase

The results at this stage are presented based on concept analysis and exploration activities in exploring mathematical concepts in Fort Marlborough. The competencies that are the focus of developing teaching materials are: explaining trigonometric ratios in right triangles (knowledge competency) and solving contextual problems related to trigonometry ratios (skills competency). Trigonometry concepts relevant to the context of Fort Marlborough include trigonometric ratios, the sine rule, the cosine rule, elevation angles, and deviation angles. Meanwhile, the results of the context analysis of Fort Marlborough concluded that several contexts could be used in presenting problems to convey the concept of trigonometry, including: measuring the height of the fort, measuring the slope of the stairs in the fort, measuring the angle of the cannon, and calculating the width of the bridge at the gate.

Prototyping stage

Characteristics Development Products

The product development of teaching materials in the form of ethnomathematics-based learning handouts in the Fort Marlborough, Bengkulu, context was designed based on the results of the self-evaluation stage and exploration activities. The resulting teaching materials are designed using ethnomathematics found at Fort Malborough as a problem in presenting the material. The design of teaching materials consists of the following initial parts: a description of the teaching materials, instructions for use, an introduction to the context, and a literacy context. The handout presents the material in text and images, including learning videos. The video contains explanations of material concepts, examples of questions and solutions, student literacy activities, and strengthening exercises. In presenting literacy activities, students are given concrete case examples to solve. Below, we provide an example of the initial part of the product, which presents the context of Fort Malborough in Figure 2.

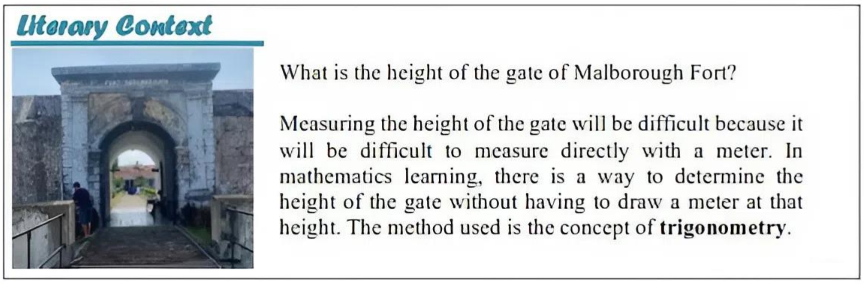


Figure 2. Example of literacy context (in english)

The core part of the learning product consists of material, examples of solving questions, and practice questions. This product also includes supporting videos that explain the material and provide examples of problem-solving. Supporting videos include barcodes and YouTube URLs. This is designed to make it easy for users to access it using smartphones. The videos in the handouts help students understand the material's concepts. Application of interactive technology in mathematics learning to improve learning quality (Miller, 2018). To understand the concept of material in teaching materials, supporting activities are needed. This product features literacy activities that allow students to experience concepts firsthand. To support literacy skills, it is necessary to incorporate literacy into every classroom lesson (Susanta et al., 2023). The design of student activities in learning handouts is an important part of teaching materials. Literacy activities are designed so students can practice them both in class and outside.

Another characteristic of this research product is the use of the Fort Marlborough ethnomathematics context in student activities. The context is designed to help students solve problems and discover concepts. This design is based on a needs analysis that showed that students struggled with mathematical visualisation when solving geometry problems. This was because the issues used unfamiliar contexts. Research by Susanta et al. (2023) showed that contexts bridge students' mathematical thinking.

Research shows that contextually based cultural learning can support student problem-solving (Samo, Darhim, & Kartasasmita, 2018). Having an ethnomathematics context will make learning more meaningful and increase students' understanding

(Charitas, Prahmana, & Ambrosio, 2020). The ethnomathematics context facilitates students' construction of mathematical concepts, including literacy (Fajriyah, 2018a). In this handout, the emphasis on context is a main characteristic of the product.

Expert and one-to-one test results

The learning handout products developed are assessed by experts, and students undergo one-to-one tests. The expert assessment focused on four aspects: appropriateness of content, presentation, language, and the use of ethnomathematics contexts in Fort Malborough. This stage is carried out through a focus group discussion (FGD). This activity was carried out in two stages: the initial stage, which explained the validity assessment instructions, and the discussion of the assessment results from each validator or assessor. The final data from three experts' assessments on each aspect were analyzed using the Aiken index. The Aiken Index is used to assess expert agreement in evaluating a product (Pandawa, Ridwan, & Mahdiyah, 2021). The Aiken index value is an index of assessors' agreement regarding the suitability of items with the necessary indicators (Retnawati, 2014), with a criterion of an Aiken index score of 0.5. The Aiken equation results from three product appraisers, are shown in Table 3.

Table 3. Results of expert assessment of learning handout products

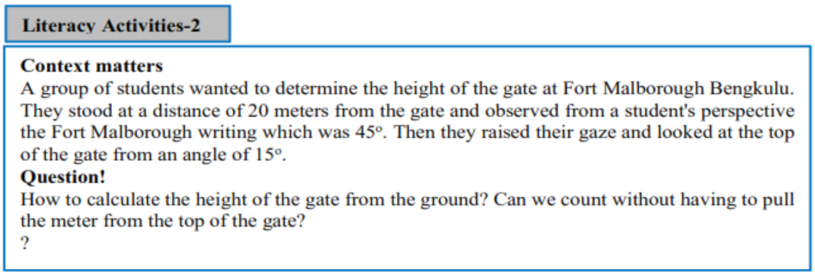
No	Aspect	Aiken Index	Information
1	Eligibility of content	0.62	Valid
2	Feasibility of Presentation	0.64	Valid
3	Language	0.72	Valid
4	Use of the Ethnomathematics Context of Fort Malborough	0.54	Valid
	Average	0.63	Valid

Based on Table 3, every aspect of the product meets the valid criteria, with an Aiken index exceeding 0.5. This concludes that, theoretically, the product has been designed according to theory, with content, presentation, language, and the use of the ethnomathematics context appropriate. The FGD activity, expert assessment, provided suggestions for the product, including that the presentation of the material should be sequential, context should be emphasized, and some writing of symbols and sentences was still inaccurate. At this stage, a one-to-one test was also conducted with six target students from public Senior High Schools in Bengkulu City. This assessment is limited to students' responses to the designed teaching materials, especially the use of the Fort Marlborough context and the product's readability. Students assess the use of context, symbols, and ease of understanding language in the product. Student assessments generally show that the problems used are quite familiar to students. Students know the context in which Fort Malborough was used. Students responded that this context had been seen at Fort Malborough. However, when discussing the context of mathematical literacy, some students said they did not understand the material's relevance. Students also find the questions difficult and say they have never been used in previous lessons or materials. Based on suggestions from validators and student assessments, the suggested results are summarized in Table 4.

Table 4. Results expert reviewer and one-to-one assessment

Expert	Sugesstion
Expert Reviewer	▪ **Validator 1:** The material is presented sequentially, and practice questions should be given in order from easy to difficult.
	▪ **Validator 2:** The existing context must be emphasized by presenting photos or drawings, and by adjusting the language and symbol angles to improve.
	▪ **Validator 3:** Please pay attention to the writing of symbols; in general, it is a good
Student	▪ If you have difficulty understanding the problems presented in the teaching materials, pictures should be provided ▪ The example questions and exercises given are still difficult to understand ▪ Some angle writing on products is not equipped with degrees ▪ Some images are still cropped

Expert reviews and student assessments were used as references for product refinement. From these revisions, considerations were made to determine which revisions should be the focus of the product revision. Several revision suggestions were reviewed in light of the theory and objectives of teaching material development. For example, the addition of relevant photos or images makes it easier for users (students) to learn with real-life problems. Furthermore, the revisions also focused on symbol writing. This is because the teaching material is designed to cover trigonometry material, so errors in symbol writing significantly affect conceptual understanding. One of the results of our product revisions is presented in Figures 3 and 4 below, specifically for student literacy activities.


Literacy Activities-2

Context matters

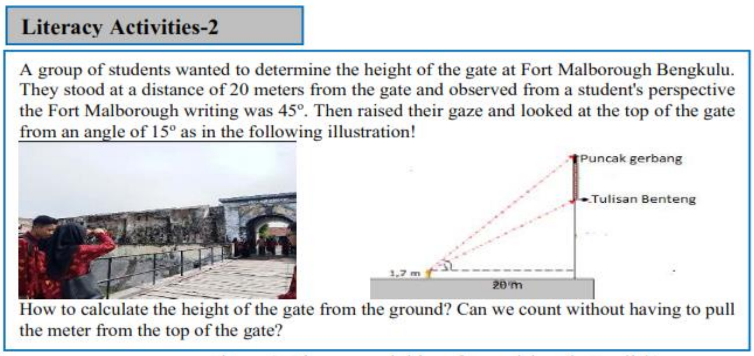
A group of students wanted to determine the height of the gate at Fort Malborough Bengkulu. They stood at a distance of 20 meters from the gate and observed from a student's perspective the Fort Malborough writing which was 45°. Then they raised their gaze and looked at the top of the gate from an angle of 15°.

Question!

How to calculate the height of the gate from the ground? Can we count without having to pull the meter from the top of the gate?

?

Figure 3. Literacy activities before revision (in english)


Literacy Activities-2

A group of students wanted to determine the height of the gate at Fort Malborough Bengkulu. They stood at a distance of 20 meters from the gate and observed from a student's perspective the Fort Malborough writing was 45°. Then raised their gaze and looked at the top of the gate from an angle of 15° as in the following illustration!

How to calculate the height of the gate from the ground? Can we count without having to pull the meter from the top of the gate?

Figure 4. Literacy activities after revision (in english)

This image shows the revisions made in response to expert advice. These revisions strengthen the contextual relevance and visual clarity of the math problem. After the revision, it is clear that the height of the gate at Fort Marlborough, Bengkulu, can be visually assessed by students, whereas previously it was presented only narratively. Without the images, students had difficulty visualizing triangles as illustrations of measurements using trigonometric ratios. This revision creates an authentic context, thus serving as a bridge between the real world and mathematics. This revision transforms the teaching material from an incomplete narrative into a clear and instructive visual guide, significantly assisting students in modelling problems using trigonometric ratios.

Small Group results

Products that have been validated and revised based on assessors' suggestions are tested on a small scale to determine the practicality of the research product in terms of readability. This test involved 12 students from two public high schools in Bengkulu City. We consider the low, medium, and high levels of student ability when assessing the practicality of using research products. This selection was made so that the information sources for product users represent all levels of student ability as product users. The products are friendly and suitable for students at all levels of thinking ability. The analysis of the assessment results for this small-group test is presented in Table 5.

Table 5. Product practicality results

Aspect	Average	Information
Appearance (images, colors, layout)	3.21	Practical
Use of font type and size on products	3.42	Very Practical
Use of Language in the Product	3.39	Practical
Use of the context of Fort Malborough	3.23	Practical
Presentation of material and exercises	3.90	Very Practical
Average	3.43	Very Practical

The results of the practicality analysis of the ethnomathematics-based trigonometry handout from Fort Marlborough, Bengkulu, based on Table 4, show that the average student assessment score for the product is categorised as very practical with a score of 3.43. The ease of use aspect measured with the highest assessment score is the presentation of material and exercises, with a score of 3.90 (very practical). This means that students assess the presentation of the material as having a logical flow and being easy to follow. In addition, the presentation of the exercises provided is relevant to the material and can be understood by students. However, the lowest student assessment is Appearance (images, colours, layout), with a score of 3.21 (practical criteria). This is because some of the images presented are not entirely understandable to students. This also serves as a basis for improving the presentation of images in problems in the teaching materials. Based on the assessment criteria, this aspect meets the practical criteria, so, in general, the appearance of the teaching materials is visually attractive to students as users.

This is the opinion of Nieveen and Folmer (2013), who stated that learning devices are practical if they are easy for users (teachers and students) to use in the field. Practicality is evident in classroom learning, with the use of high-quality products (Hafiz, 2013). This makes the practical aspect of a learning product essential to achieving learning objectives effectively. The theory states that the practical benefits of learning media will increase students' motivation to interact with one another (Arsyad, 2016).

Field Test

The final stage of this research is a large-scale trial in which the developed product serves as the primary source of learning. Teachers are asked to implement learning using the developed learning handouts. After learning using handouts, students are given literacy tests. The product trial stage was conducted during one learning meeting (3 x 45 minutes) with 43 students from two public senior high schools in Bengkulu City. The effectiveness of the development product was tested using a literacy test on trigonometry material on students. The test is given after students use the product in learning. The test is conducted for 60 minutes, with five literacy questions in the form of descriptions. The student's literacy scores were converted to a 100-point scale. The results of the analysis of students' literacy tests in the wide-scale trial were 64.57 with a standard deviation of 6.49. This data shows that, on average, students' literacy abilities resulting from learning with handouts are in the medium range. Even though the average score is 64.57, students have met the medium-to-high criteria across the categories. On average, students' mastery of trigonometry material literacy is good. An overview of students' literacy abilities based on test results is in Table 6.

Table 6. Literacy ability of students

Score Intervals	Criteria	Number of students	Percentage
0-33	Low	7	16.28 %
34-66	Medium	22	51.16 %
67-100	High	14	32.56 %

Based on the table above, some students meet the medium and high criteria. This shows the handout is effective in reviewing the increase in literacy skills among high school students, as evidenced by the high category percentage of 32.5%. Although more than half (51.16%) of students were in the sufficient category, this still had a significant impact. This was due to the low initial literacy skills observed in the target schools. Achieving moderate to high criteria with these learning materials demonstrates their effectiveness in supporting students' mathematical literacy. Students who tended to solve routine problems were able to achieve sufficient and high criteria after using these learning handouts.

Additionally, we also highlight student achievement on each measured question indicator. The distribution of student achievement on each indicator, with scores ranging from 0 to 5, is shown in the following graph.

Figure 5 shows that the percentage distribution of students' abilities across all indicators falls within the high criteria. This is indicated by the fact that more than 50% fall within the high category. This data suggests that students' mathematical literacy achievements, as a result of using the developed learning handouts, fall within the high category.

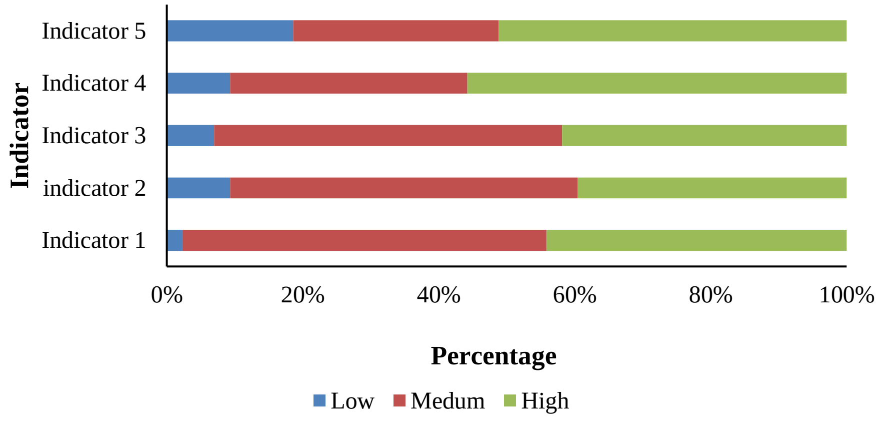


Figure 5. Student achievement in each indicator

Data on students' literacy abilities after learning with handouts based on Fort Marlborough ethnomathematics indicate an average level of medium to high. Based on this, it can be concluded that the learning handouts are effective in developing high school students' literacy skills in trigonometry material. The results of this research are supported by empirical data from previous research, which show that the use of ethnomathematics contexts in learning affects student learning outcomes. The findings of this research indicate that teaching materials in the form of ethnomathematics-based learning handouts for Fort Malborough Bengkulu have the potential to impact students' trigonometry literacy activities.

Furthermore, a quantitative analysis was conducted to examine the effect of using teaching materials on students' mathematical literacy skills. The study used a one-way ANOVA to examine differences in students' literacy skills across initial cognitive levels (low, medium, and high). The results of the analysis of differences in average literacy skills using the one-way ANOVA test are presented in Table 7 below.

Table 7. Results of the difference test (one-way anova)

	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	1138.191	2	569.09	1.28	.289
Within Groups	17792.414	40	444.81		
Total	18930.605	42			

Table 7 shows that there was no difference in literacy skills between low-, medium-, and high-ability students after using the learning handout. This is indicated by the p-value of 0.289 (greater than 0.05), suggesting that the difference in mathematical literacy scores across the three cognitive groups was not statistically significant. The data from this analysis indicate that the use of the developed trigonometry learning handout affects students' mathematical literacy. The increase in ability is not due to the students' cognitive skills but to the use of the learning handout.

Qualitatively, this study's results indicate an impact on students' literacy skills, as demonstrated in their problem-solving processes. This data shows that the potential impact of learning using handouts supports student literacy. We present an example of student literacy activities in classroom learning in Figure 6.

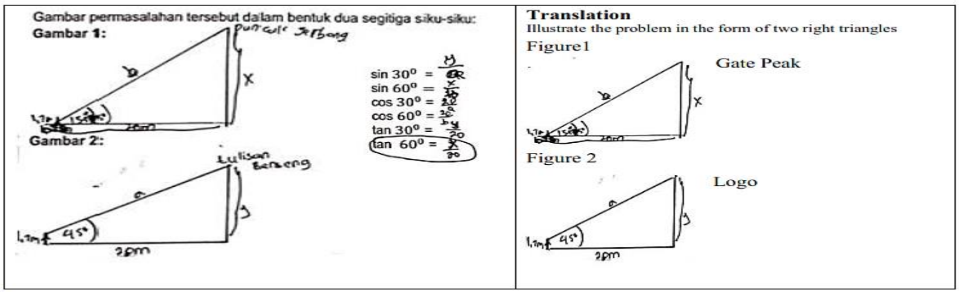


Figure 6. Examples of student work on literacy activities

Based on the image above, students have been able to solve the problem in the question using trigonometric ratios. Students have correctly carried out the steps, starting with describing the situation using a right-angled triangle model. In addition, students correctly identified the angles in the problem and applied them to the triangle shown in the image. In addition, students have used the appropriate trigonometric ratios or comparisons (sin, cos, tan) along with the corresponding sides. In general, students' solution stages have demonstrated a systematic mathematical thinking process that starts with understanding the real situation, converting it into mathematical form, selecting the appropriate formula, and arriving at a solution. This shows that students have the mathematical literacy skills to solve real-world problems.

The results of this research indicate that using an ethnomathematics context affects how students carry out literacy activities, particularly when using more familiar problems. This research aligns with previous findings, which show the influence of ethnomathematics and local contexts on students' mathematical literacy (Sarwoedi et al., 2018; Fajriyah, 2018; Kolar & Hodnik, 2020). The use of ethnomathematics in a more familiar context, such as Fort Marlborough, in this research makes it easier for students to accept the material. In this study, the role of context, using ethnomathematics in the context of Fort Marlborough, in presenting concepts, provided students with a different visualization of the problem. Students' interest in the context they understood supported their mathematical visualization of the problem. This was evident in how students illustrated the problem using trigonometric ratios in right triangles. This aligns with the views of Risdiyanti & Prahmana (2020), who argue that mathematics and local culture in everyday life, namely ethnomathematics, can bridge the understanding of mathematics. Other research shows that realistic learning in a cultural context can improve mathematical communication skills, including literacy (Susanto, Susanta, Rusnilawati, & Ali, 2024).

▪ CONCLUSION

Based on the research results and discussions presented, the ethnomathematics-based learning handout of Fort Malborough Bengkulu meets the criteria of validity, practicality, and effectiveness for students' literacy skills. The validity results are shown in the expert assessment quantitative score (0.63; valid criteria) and in improvements from assessor suggestions. This learning handout has also met the practical criteria through user assessment, with an average student response score of 3.43 (very practical). The handout product also meets the effectiveness requirement through wide-scale classroom implementation, thereby improving students' mathematical literacy.

The results of this study have implications for the development of similar teaching materials, particularly those supporting the implementation of the Independent Curriculum, which emphasizes real-world context-based learning. Furthermore, effective learning handouts that enhance mathematical literacy skills by using real-world contexts grounded in ethnomathematics can encourage active learning. Moreover, this study has limitations, particularly in the selection of test subjects, which were limited to a single school. Therefore, as a recommendation, in addition to using ethnomathematics contexts, it is necessary to pilot the materials across a broader range of subjects and thoroughly examine their appropriateness to ensure student understanding.

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