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Development of Mathematical Literacy Problems Based on the Ethnomathematics of Acehnese Culture

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Abstract: This study aims to develop mathematical literacy problems based on the ethnomathematics of Acehnese culture. This study is motivated by the lack of resources relevant to local culture, which has hindered Acehnese mathematics teachers from implementing ethnomathematics in their classrooms. Ethnomathematics is regarded as an effective approach to enhance students' mathematical literacy. Moreover, the integration of culture into mathematics learning has also become part of a government program in response to the low mathematical literacy performance of Indonesian students in the Program for International Student Assessment (PISA). This developmental research employed the Thiagarajan Four-D model, comprising Define, Design, Development, and Disseminate. However, this study focused only on the first three phases. The define phase entails a systematic needs analysis encompassing curriculum, student characteristics, and conceptual aspects. The design phase produces a preliminary prototype of mathematical literacy problems contextualized in Acehnese culture. The develop phase involves expert validation and iterative evaluation through one-to-one evaluations, small-group trials, and classroom field testing, with revisions incorporated to enhance validity, reliability, and pedagogical relevance. This study involved 41 students from a senior high school in Aceh and five validators. Data were gathered from validation and practicality questionnaires, interviews, and tests. Data were then analyzed descriptively. The result revealed that 19 out of 20 problems were valid. The problems were also considered practical and potentially effective for implementation in mathematics classrooms. The development of these problems provides a useful resource for mathematics teachers in Aceh. The study result suggests that ethnomathematics problems are beneficial in improving students' mathematical literacy. The value of culture embedded in the mathematical problems raises students' awareness and understanding of their local culture. These findings suggest that integrating local culture into mathematics instruction can help teachers design meaningful learning experiences that enhance both mathematical understanding and cultural awareness.

Keywords: acehnese culture, developmental research, ethnomathematics, mathematical literacy problem, mathematics learning.

▪ INTRODUCTION

Mathematical literacy is a fundamental skill that students are expected to possess and is assessed in the Program for International Student Assessment (PISA) by the Organization for Economic Cooperation and Development (OECD). However, the mathematical literacy of Indonesian students consistently falls below the OECD average. Based on the PISA results, Indonesia ranked 70th in 2022 and 71st in 2018 for mathematics achievement (OECD, 2023). Although Indonesia's ranking improved, the score declined compared to the achievement in 2018. In 2022, the score declined by 13 points, reaching 366, significantly below the OECD average of 472. The result implies that teachers need to work harder to enhance students' mathematical literacy. Since 2015,

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the Ministry of Education and Culture of the Republic of Indonesia has been actively promoting the National Literacy Movement as a strategic initiative to enhance students' literacy competencies, including mathematical literacy, through the integration of literacy activities in the teaching and learning process (Kementerian Pendidikan dan Kebudayaan, 2017).

However, in practice, mathematics learning at schools has not been fully grounded in literacy-based approaches, contributing to students' low mathematical literacy. Monotonous mathematics learning dominated by routine problems exacerbates this issue. Additionally, teachers face substantial impediments in implementing transformative shifts in their pedagogical practices. The majority of mathematics textbooks include a few problems promoting mathematical literacy, and the mathematics curriculum puts limited emphasis on developing this skill (Genc & Erbas, 2019). Furthermore, students often find mathematics unengaging (Utha, Subba, Mongar, Hopwood, & Pressick-Kilborn, 2023) and less applicable to their lived experiences (Fitzmaurice, O'meara, & Johnson, 2021). Therefore, one way to make mathematics more relevant to students is by integrating the contexts of local culture (Pang, Alvarado, Preciado, & Schleicher, 2021; Thomas, Berry, & Sebastian, 2024)

The integration of culture and mathematics learning can be realized through an ethnomathematics approach. Ethnomathematics supports mathematical literacy skills by involving complex mathematical reasoning skills and problem-solving in various situations (Rosa & Orey, 2015). By incorporating cultural contexts, this approach enhances students' cultural awareness and fosters a greater sense of appreciation and concern for their culture (Harding, 2022; Prahmana, 2022). Besides, ethnomathematics encourages students to see connections between mathematics and real-world experiences, specifically culture (Orey & Rosa, 2021) and improves their understanding of mathematical concepts (Sari et al., 2023). Thus, ethnomathematics-based learning is effective in increasing students' mathematical literacy (Pratama & Yelken, 2024).

Ethnomathematics has been implemented globally. For instance, in Africa, the curriculum recommends integrating ethnomathematics into mathematics teaching and learning (Sunzuma & Maharaj, 2021a). In Nigeria, research indicates that incorporating ethnomathematics in classroom practice effectively enhances students' mathematical achievement (Kyeremeh, Awuah, & Dorwu, 2023). Furthermore, ethnomathematics has been shown to transform students' attitudes toward mathematics and increase the relevance of learning by connecting it to their cultural contexts (Motseki, Jojo, & Gumbo, 2025). Despite these promising outcomes, African teachers still face challenges in integrating mathematical concepts through ethnomathematics due to limited resources (Meeran, Kodisang, Moila, Davids, & Makokotlela, 2024; Sunzuma & Maharaj, 2021b, 2022). Consequently, additional support and professional development are necessary to help teachers effectively implement ethnomathematics in their classrooms (Meeran et al., 2024).

In Latin America, the national curriculum has been integrated with the ethnomathematics curriculum (Parra et al., 2021), aiming to foster both students' mathematical and ethnomathematical competencies (Näslund-Hadley et al., 2025). Research reported that the implementation of ethnomathematics in Latin American schools has been effective in enhancing students' learning outcomes (Näslund-Hadley et al., 2025). Nevertheless, several challenges have been identified, including insufficient

teacher training on socio-cultural dimensions (Gavarrete, 2015), the limited availability of ethnomathematics courses in teacher education programs, a scarcity of relevant textbooks, and the absence of assessment instruments aligned with the ethnomathematics curriculum (Orey & Rosa, 2007).

In Australia, ethnomathematics are embedded in the curriculum through the inclusion of indigenous mathematics within the school mathematics curriculum (Xu & Ball, 2024). The curriculum prioritizes Aboriginal and Torres Strait Islander content, and the Australian Professional Standards for Teachers explicitly highlight strategies for teaching Aboriginal and Torres Strait Islander students (O'Keeffe, Paige, & Osborne, 2019). Although the term "ethnomathematics" is not explicitly used, the standards emphasize the integration of culture and mathematics, reflecting the principles of culturally responsive pedagogy. Nevertheless, research documenting the classroom implementation of ethnomathematics remains limited (Civil, 2002). More recent studies (Edmonds-Wathen, 2017; Edmonds-Wathen & Gumurdal, 2024) have primarily focused on indigenous students, particularly exploring how mathematics can be taught through their languages and cultural practices to foster engagement and achievement. Although ethnomathematics practice is evident in the Australian curriculum, professional capacity to teach and support the mathematics achievement of indigenous students remains uneven, with stronger emphasis at the early childhood and primary school levels, while secondary education receives limited attention (Anderson, Yip, & Diamond, 2023).

In Indonesia, cultural integration in learning has also become a national curriculum demand. The recent Indonesian national curriculum suggests that teachers design lessons relevant to students and situated in cultural contexts (Payadnya, Wulandari, Puspadewi, & Saelee, 2024). Although research on ethnomathematics in Indonesia has grown considerably, its classroom implementation remains limited, fragmented, and inconsistent across the vast number of districts and regions, particularly in remote and very remote areas. Furthermore, the use of ethnomathematics has not been sustained over time, as many initiatives tend to be temporary or project-based, with little evidence of long-term integration into regular teaching practices. The major challenges in implementing culture-based learning in schools lie in the limited inclusion of ethnomathematics in the national curriculum, teachers' insufficient knowledge of ethnomathematics, and the scarcity of accessible learning resources related to ethnomathematics (Mania & Alam, 2021). Specifically in Aceh, these challenges create barriers for Acehnese teachers in implementing the curriculum that embeds local culture (Maulina, Junaidi, Taufiq, & Maulida, 2023). In some cases, teachers even exhibit reluctance to integrate ethnomathematics into their mathematics classrooms. Such factors contribute to the persistently low levels of mathematical literacy among students in local schools. Consequently, there is a pressing need to design ethnomathematics-based mathematical literacy problems situated in the Acehnese local context, in order to support teachers in overcoming these obstacles.

Several researchers have also developed mathematical literacy problems based on ethnomathematics (Breda et al., 2023; Oktiningrum, Zulkardi, & Hartono, 2016; Usnul, Johar, & Sofyan, 2019). However, the results of a bibliometric study found that ethnomathematics research related to mathematics problems is still scarce (Tamur, Wijaya, Nurjaman, Siagian, & Perbowo, 2023). Accordingly, research focused on the development of ethnomathematics-based mathematics problems remains critically

necessary, particularly within the context of Acehnese culture. Only four past studies (Gradini, & Saputra, 2021; Salsabila, Johar, Yuhasriati, Yanti, & Suryawati, 2023; Usnul et al., 2019; Wahyuni, 2023) were found in the body of literature related to the development of mathematical literacy problems in Acehnese cultural contexts. Usnul et al. (2019), Gradini et al. (2021), and Wahyuni (2023) have designed mathematical literacy problems equivalent to PISA problems for secondary school level students. On the other hand, Salsabila et al. (2023) referred to the Minimum Competency Assessment or *Asesmen Kompetensi Minimum* (AKM) problems as the framework to design mathematical literacy problems. Distinct from previous works, the problems developed in this study were constructed in essay format to encourage deeper reasoning and to ensure their suitability for classroom implementation.

In response to the scarcity of relevant research, this study aims to design mathematical literacy problems based on the ethnomathematics of Acehnese culture, which is valid, practical, and effective. Addressing the limited proportion of ethnomathematics research conducted at the high school level (Turmuzi, Suharta, & Suparta, 2023), this study specifically targets the senior high school level. Through this novelty, the findings of this study will enrich the body of literature on mathematical literacy problems within the Acehnese cultural context and provide practical resources for Acehnese mathematics teachers to enhance students' mathematical literacy. This study proposes a research question: how is the validity, practicality, and effectiveness of the mathematical literacy problems based on the ethnomathematics of Acehnese culture

▪ METHOD

Participants

This study was conducted at one of the senior high schools in Banda Aceh, Aceh, Indonesia. The study included a total of 41 students. All these students confirmed their consent to participate in this study. Participants were assured that their responses would remain confidential and be used solely for research purposes. To maintain confidentiality, all data were anonymized, identifying information was removed, and responses were stored securely with access restricted to the research team.

Three students were involved in a one-to-one evaluation, six students in a small-group trial, and 32 students in the field test. Students participating in the one-to-one evaluation and small-group trial were different from those participating in the field test. The participants were chosen purposively based on the criteria: having learned the topics examined in the problems and showing willingness to collaborate in this study. In this study, students' academic abilities were not strictly controlled; thus, participants with varying levels of mathematical achievement were included in the field test. This decision was made because the purpose of the study was to evaluate the practicality and effectiveness of the ethnomathematics-based mathematical literacy problems in a natural classroom setting. As a result, the diversity of student characteristics, including differences in academic ability, was preserved, allowing the findings to better represent real classroom conditions. This study also involved five validators, comprising one mathematics education lecturer and four mathematics high school teachers. One validator had research experience and publications in ethnomathematics, while the others had professional expertise in developing tasks within cultural contexts. All validators possessed 20-30 years of teaching experience.

Research Design and Procedures

This research constitutes a research and development (R&D) using the Thiagarajan Four-D model, consisting of define, design, development, and disseminate (Thiagarajan, Semmel, & Semmel, 1974; Yunus & Fransisca, 2021). However, this article concentrates on the first three phases: define, design, and develop, which will be described as follows.

Define

The define phase involves identifying and specifying the requirements for product development. At this stage, a comprehensive needs analysis is conducted, as in this study, which includes curriculum analysis, student characteristics analysis, and conceptual analysis relevant to the design of the product. The curriculum was analyzed to determine the mathematics content used in the problems. The information about student characteristics was employed to design the problems tailored to their level. Conceptual analysis was conducted to identify problems relevant to learning objectives, cultural contexts, and student levels.

Design

The design phase focuses on creating an initial prototype, specifically a preliminary draft of mathematical literacy problems contextualized within Acehnese culture. The problems were designed based on the mathematics curriculum of grade 10 and the mathematical literacy framework derived from OECD (2023).

Develop

The develop phase encompasses the validation and evaluation of the prototype's feasibility. This includes expert appraisal, one-on-one evaluations, small-group trials, and fieldtesting involving students in actual classroom settings. The validators contributed by reviewing the content, construct, and language of the problems, while also offering suggestions for refinement. Their feedback was used to improve the quality and validity of the final problems. During a one-to-one evaluation, three students solved the problems to check the readability and clarity. After revision, the problems were distributed to six students during a small-group trial. They were also asked to fill out the questionnaire to assess the practicality of the problems. In the field test, the problems were administered to 32 students to evaluate their effectiveness in developing students' mathematical literacy. This test was administered once after they studied mathematics topics assessed in the problems at school. This study did not implement a teaching intervention and did not assess students' ability prior to the intervention; therefore, the post-test is sufficient. Revisions were then made iteratively based on the results of each evaluation to ensure that the problems are valid, reliable, and suitable for instructional use.

Instrument

The instruments used in this study include validity and practicality questionnaires, interviews, and tests. The validity questionnaire consists of three aspects: content, construct, and language. Meanwhile, the practicality questionnaire consists of six statements adopted from Maidiyah, Agusta, Johar, Saputri, & Andayani (2023). The test consisted of 20 essay problems, which the researchers developed specifically for this study. The test was designed in alignment with the Grade 10 mathematics curriculum and the Mathematics Literacy Framework. The mathematical content employed in the test

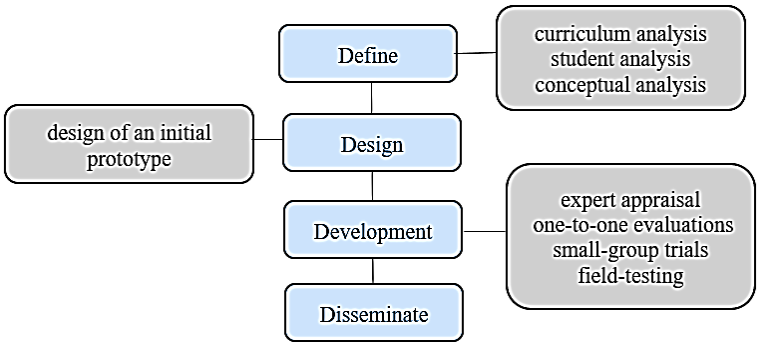


Figure 1. Research design

includes number, data analysis, and probability, while the subtopics involve sequences and series, statistics, and probability. The mathematical literacy framework adopted in this study was proposed by OECD (2023) which comprises three key processes: formulating, employing, and interpreting. Formulating involves the ability to identify the mathematical structures embedded within a problem or situation and simplify it by breaking down the problem into manageable pieces of information. Employing pertains to executing basic calculations, formulating and applying appropriate strategies, utilizing mathematical facts, rules, and procedures to derive solutions, and drawing generalizations from the outcomes. Interpreting entails assessing the obtained results in relation to the context in which the problem is situated. All of these aspects were also used to develop a rubric for assessing students' answers. A brief description of the problem set is provided in Table 1.

Table 1. Test description

Mathematics Literacy Aspect	The Number of Problems	Math Content/Topic	Context
Formulating	7	Number, Probability/ Sequence and series, Probability	Acehnese Traditional house, Acehnese tradition.
Employing	7	Number, Probability/ Sequence and series, Probability	Acehnese Traditional house, Acehnese tradition.
Interpreting/ Evaluating	6	Number, Data Analysis, Probability/ Sequence and series, Statistics, Probability	Acehnese Traditional house, Acehnese tradition, Acehnese language.

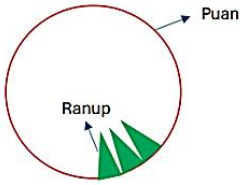
Problems that involve the formulating aspect require students to identify mathematical structures within a given situation. For example, Question 4 asks students to determine the number of ranup in the first layer. This item corresponds to the learning indicator *"identifying arithmetic sequences and series."* Figure 2 shows a problem in formulating the aspect.

Ranup

Sumber: https://www.gppmaceh.com/2021/03/sirih-dalam-adat-aceh.html#google_vignette

Dalam adat Aceh, ranup merupakan simbol prosesi atau pengawal kegiatan yang memiliki makna kemuliaan (pemulia jamee). Biasanya ranup diletakkan di dalam sebuah wadah yang disebut *bate ranup* (puan) yang melambangkan keindahan budi pekerti dan akhlak yang luhur. Wadah tersebut sebagai satu kesatuan yang melambangkan sifat keadatan.

Pada persiapan suatu acara adat, Ani dan Sari menyiapkan ranup hiasan pada sebuah puan yang memiliki diameter 28 cm. Mereka ingin merangkai ranup dengan menjejerkan ranup dipinggir puan pada lapisan pertama, kemudian menyusunnya lagi di atasnya sebagai lapisan kedua dan seterusnya dan sampai membentuk setengah bola. Sebelum disusun, pertama-tama mereka membuat ranup membentuk kerucut dengan panjang alas 2 cm dan tinggi 6 cm seperti pada gambar di bawah ini.



4. Berapa ranup yang diperlukan untuk lapisan pertama?

Figure 2. A problem in the formulating aspect

Problems related to the employment aspect require students to perform basic calculations and apply appropriate strategies or procedures to obtain solutions. For instance, in Question 5, students are expected to solve an arithmetic sequence and series problem in the ranup context. It aligns with the learning indicator *"solving contextual problems related to arithmetic sequences and series."* Figure 3 illustrates a problem in employing the aspect.

5. Jika jumlah ranup pada lapisan kedua berkurang 2 dari jumlah pada lapisan pertama dan lapisan terakhir berjumlah 4 ranup, berapa total lapisan ranup yang perlu mereka susun agar hiasan sempurna? Berapa pula jumlah ranup yang diperlukan untuk membuat ranup hiasan tersebut?

Figure 3. A problem in the employing aspect

Meanwhile, problems targeting the interpreting or evaluating aspect require students to assess or justify results and provide logical reasoning for their responses. As illustrated in Question 6, students were asked to express agreement or disagreement with a given statement and to support their stance with arguments. This question also reflects the learning indicator *"evaluating statistical reports and data representations."* Figure 4 depicts a problem in interpreting/evaluating the aspect.

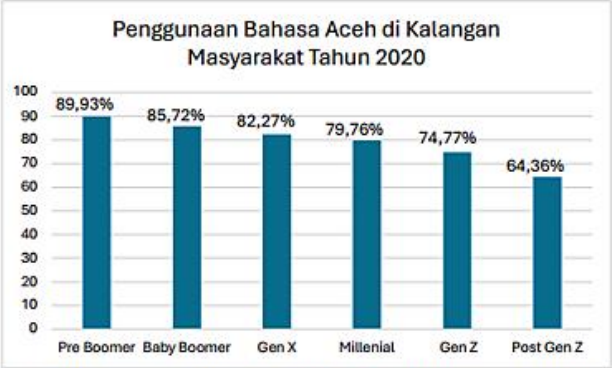
Penggunaan Bahasa Daerah Aceh Mulai Ditinggalkan Generasi Muda

Banda Aceh (ANTARA) - Badan Pusat Statistik (BPS) Aceh menyatakan bahwa berdasarkan laporan long form sensus penduduk 2020, penggunaan bahasa daerah Aceh berkurang di kalangan post gen Z yang lahir 2013 ke atas dibandingkan generasi pre boomer (lahir sebelum 1945). "Penggunaan

bahasa daerah oleh post gen Z (2-9 tahun) sebesar 64,36 persen, angka ini jauh berkurang dibandingkan generasi pre boomer (di atas 75 tahun) yang jumlahnya mencapai 89,93 persen," kata Koordinator Fungsi Statistik Sosial BPS Provinsi Aceh, Dadan Supriardi, di Banda Aceh, Jumat.

Dadan menyampaikan, penggunaan Bahasa Aceh secara berangsur-angsur menurun pada generasi selanjutnya, misalnya pre boomer (mulai usia 77 tahun) sebesar 89,93 persen, lalu pada baby boomer (58-76 tahun) sebesar 85,72 persen. Angkanya terus menurun pada generasi gen X (42-57 tahun) sebesar 82,27 persen, millenial (26-41 tahun) 79,76 persen, gen Z (10-25 tahun) sebesar 74,77 persen, dan generasi paling muda post gen Z (2-9 tahun) jumlahnya turun lagi menjadi 64,36 persen.

Sumber: https://www.antaranews.com/berita/3379269/bps-penggunaan-bahasa-daerah-aceh-mulai-ditinggalkan-generasi-muda



Gambar 1. Grafik Penggunaan Bahasa Aceh di Kalangan Masyarakat Aceh Tahun 2020

Sementara itu, data penduduk Aceh berdasarkan klasifikasi generasi pada tahun 2020 ditampilkan pada tabel berikut.

Generasi	Laki-laki	Perempuan	Total
Post Gen Z	399.859	382.332	782.191
Gen Z	786.524	745.373	1.531.897
Millenial	695.067	682.820	1.377.887
Gen X	492.223	499.071	991.294
Baby Boomer	243.487	269.378	512.865
Pre Boomer	30.403	48.334	78.737

Sumber: https://sensus.bps.go.id/topik/tabular/sp2020/2/0/0

6. Apakah kamu setuju dengan pernyataan: "Jumlah Generasi Pre-Boomer yang berbicara Bahasa Aceh lebih banyak daripada Jumlah Gen X yang berbicara Bahasa Aceh." Berikan alasanmu.

Figure 4. A problem in the interpreting/evaluation aspect

Data Analysis

The data collected in this study were analyzed descriptively to provide an overview of the validity, practicality, and effectiveness of the developed ethnomathematics-based mathematical literacy problems. van den Akker et al. (2006) state that a product is considered valid if it is developed based on established knowledge or scientific principles (content validity), and if its components are logically consistent and coherent with the overall design (construct validity). Aiken's validity coefficient was employed to evaluate content validity assessed by experts, and Pearson's product-moment correlation coefficient was used to measure the extent to which the items accurately reflect the intended constructs through the field test. The practicality of the problems was determined through analysis of students' responses to the practicality questionnaire, where the percentage of responses served as an indicator of the problems' ease of use, clarity, and applicability in classroom settings. The effectiveness of the problems was measured by calculating the mean score of students' performance on a test, which served as an

indicator of the problems' capacity to enhance students' mathematical literacy. The students' score was then categorized based on the criteria proposed by Ajizah, Karim, & Suryaningsih (2023), as listed in Table 2. The results obtained from these analyses were then interpreted and discussed in relation to the study's objectives and the relevant literature.

Table 2. Criteria for students' scores (ajizah et al.,2023)

Score	Criteria
100	Excellent
$75 \leq$ score < 100	Good
$50 \leq$ score < 75	Fairly good
$0 \leq$ score < 50	Poor

▪ RESULT AND DISSCUSSION

This study produced mathematical literacy problems using ethnomathematics contexts of Acehnese culture for high school students using the Thiangarajan Four-D model (Thiangarajan et al., 1974): define, design, develop, and disseminate (Yunus & Fransisca, 2021). This article focused only on the first three phases, which will be scrutinized below.

Define

In the define stage, a comprehensive analysis was carried out to guide the development of mathematical literacy problems. This analysis encompassed three main aspects: mathematics curriculum analysis, students' characteristics, and conceptual analysis. The mathematics curriculum analysis was conducted to ensure alignment with the curriculum by reviewing curriculum documents and textbooks, as well as identifying mathematical topics taught at the targeted grade level. The analysis of students' characteristics aimed to determine their level of understanding and prior knowledge. Meanwhile, the conceptual analysis was undertaken to specify the precise learning objectives and to select cultural contexts appropriate to the students' level. Based on these analyses, the researchers identified suitable mathematical topics and culturally relevant contexts to be integrated into the problem design and compiled a preliminary list of problems for further development. The mathematical domains chosen for this study included sequences, statistics, and probability, as these topics align with both high school mathematics curriculum objectives and the potential for contextualization through cultural narratives. In terms of cultural integration, the researchers incorporated cultural elements such as traditional practices, the Acehnese traditional house, and the Acehnese language to ground the problems in authentic and meaningful contexts. Pedagogically, the choice of these three contexts provides relevance for students, as they learn through cultural experiences that are more familiar to their daily lives. Mathematically, these contexts contain explicit mathematical structures and patterns that can be transformed into mathematical problems related to topics aligned with students' level, allowing them to engage in mathematization at their own level. Compared to other contexts, local contexts are more effective in bridging abstract concepts into concrete understanding and in strengthening mathematical literacy within students' cultural backgrounds. This alignment between mathematical content and cultural representation aimed to enhance

students' engagement and foster mathematical literacy and understanding through ethnomathematics-based learning materials (Kurniawan, Purwoko, & Setiana, 2023).

Design

During the design stage, the researchers identified the types and format of problems, developed the assessment rubric, and created the initial prototype. The researchers chose the essay format because these problems are designed to serve as classroom activity tasks for students, rather than a standard test. Through solving problems, students were expected to develop their mathematical literacy. In addition to enhancing students' mathematical literacy, the problems aim to instill students' cultural awareness and knowledge. Thus, reading texts about culture was also provided to understand the cultural context that embedded the mathematical problems. The culture encompasses the motif design of Aceh traditional houses, activities within Aceh traditional houses, *ranup* arrangements, the use of Acehnese language, *peusijuek*, Maulid traditions in Aceh, and *khanduri*. An example of a reading text on *peusijuek* is depicted in Figure 5.

Bacaan Untuk Soal 10-11

Upacara *Peusijuek*

Sumber: https://id.theasianparent.com/peusijuek

Peusijuek disebut juga tepung tawari. Bagi masyarakat Aceh, upacara ini dianggap simbol dari permohonan keselamatan, ketentraman, kebahagiaan, perestuan dan saling memaafkan. Hampir sebahagian adat Aceh memiliki prosesi upacara *peusijuek*, seperti upacara perkawinan, sunat rasul, aqiqah anak, *peusijuek* rumah baru, *peusijuek* naik haji, dan sebagainya. Biasanya dalam pelaksanaan *peusijuek* dihadirkan seorang *Teungku* (ulama) atau orang yang dituakan (Majelis adat) sebagai pemimpin prosesi *peusijuek*.

Pada suatu acara sunat rasul, seorang MC akan membuat daftar urutan nama-nama yang akan melakukan *peusijuek* kepada seorang anak. Seorang anak akan dipeusijuk oleh seorang teungku, kedua orang tuanya, nenek dan kakek, serta tiga anggota keluarga lainnya.

Figure 5. A culture reading text provided before questions

Further, the problems were designed in alignment with the mathematical literacy framework. At this stage, an initial draft was produced, consisting of 20 questions: seven questions for sequences and series, four questions for statistics, and nine questions for probability. All these math subtopics are under the mathematics content: number, statistics, and probability. These mathematics topics were chosen because they are part of the grade 10 mathematics curriculum and are suitable for the selected cultural contexts. The design of Aceh traditional houses and ranup arrangements embed patterns that match

the sequence and series topic. The context of the Acehnese language provides data representation and data analysis relevant to the statistics topic. The contexts of *peusijuek, maulid,* and *khanduri* traditions were used for the probability topic since the process of these traditions entails the concept of probability, for example, the probability of a man picking an idang in a maulid tradition.

Develop

Afterwards, in the develop stage, the initial prototype obtained in the first stage was validated theoretically and empirically. A panel of five experts conducted theoretical validation. The expert appraisal was administered to validate the content, construct, and language of the problems (Almanasreh, Moles, & Chen, 2019). Content refers to the alignment of problems with mathematical content and cultural contexts. Construct constitutes the alignment of the problems with the mathematical literacy framework. Language includes the clarity and readability of the problems. In this validation questionnaire, experts are required to rate a score ranging from 1 to 4, where 1 corresponds to 'irrelevant/unclear' and 5 corresponds to 'highly relevant/clear'. Then, the validators' scores were analyzed using Aiken's content validity. The analysis result of the expert validation is listed in Table 3 below.

Table 3. The result of expert validation

Aspect	***Aiken's V***
Content	
The alignment of problems with mathematical content in Grade 1 of the senior high school level	1
The alignment of problems with Acehnese culture	1
Construct	
The alignment of the questions with the reasoning ability	0.87
The alignment of the questions with the mathematical literacy framework (formulating, employing, interpreting)	1
Language	
The language complies with Indonesian language standards	0.93
The language used is clear, unambiguous, and easy to understand.	0.80
Average	**0.93**

The final result from the expert validation process yielded an average Aiken's content validity coefficient (V) of 0.93. The product is declared valid if the coefficient is greater than 0.78 for five raters and four scales (Aiken, 1985; Utaminingsih & Ellianawati, 2025). Therefore, the problems in this prototype are declared valid and can proceed to the developmental testing stage.

However, among the three aspects assessed, the lowest validity coefficient (0.80) lies in the aspect of clarity and readability of language. This is consistent with the comments from validators, which primarily focused on the language and content aspects. The validators suggested that the problems should be adjusted to suit the students' level and that the language should be improved, as some ambiguous words were identified. Table 4 shows some general comments from validators.

Table 4. Validators' comments

Criteria/Aspect	Validator Comment
Content (the alignment of questions with mathematical contents and cultural contexts)	Well-structured, covering various concepts, namely sequences and series, probability, geometry, and combinatorics. Each question is closely connected to Acehnese culture, enriching students' understanding of the relationship between culture and mathematics.
Construct (the alignment of the questions with the mathematical literacy framework)	The questions encourage students to use logical reasoning. Each question fosters students' critical thinking and mathematical literacy by encouraging them to formulate, apply, and interpret mathematical concepts.
Language (the clarity and readability of the questions)	The majority of questions have been well-structured, but you still need to pay attention to the Enhanced Spelling System [Indonesian: EYD], such as capitalization and italics. The question wording is mostly clear, but some items still need improvement in sentence choice to avoid confusion.

The problems were then revised based on the validators' suggestions. Specifically, a validator's comment for Question 5 is presented in Table 5 below, and its revision is depicted in Table 6.

Table 5. An example of a validator's comment

Question	Validator Comment
Jika jumlah ranup pada lapisan kedua berkurang 2 dari jumlah pada lapisan pertama dan lapisan terakhir berjumlah 4 ranup, berapa total lapisan ranup yang perlu mereka susun agar hiasan sempurna? Berapa pula jumlah ranup yang diperlukan untuk membuat ranup hiasan tersebut? **Translated:** If the number of *ranups* in the second layer is two less than in the first layer, and the last layer contains four *ranups*, how many total layers of *ranups* do they need to arrange for a perfect decoration? Furthermore, how many *ranup* are needed in total to create the decoration?	*Soal No. 5 ambigu, terutama pada kalimat "lapisan kedua berkurang 2 dari jumlah pada lapisan pertama". Kalimat tersebut dapat memiliki makna "hanya di lapisan ke-2 saja yang berkurang sebanyak 2 buah", tapi ternyata yang berkurang itu semua lapisan. Maka perlu direvisi soalnya.* **Translated:** Question No. 5 is ambiguous, especially in the sentence "the second layer is two less than in the first layer." This sentence could mean "only the second layer is reduced by 2," but it turns out that all layers are reduced. Therefore, the question needs to be revised.

Table 6. Revision for question 5

Before Revision	After Revision
Jika jumlah ranup pada lapisan kedua berkurang 2 dari jumlah pada lapisan pertama dan lapisan terakhir berjumlah 4 ranup, berapa total lapisan ranup yang perlu	*Jika jumlah ranup pada lapisan kedua dan seterusnya berkurang sebanyak 2 buah dari jumlah pada lapisan sebelumnya dan lapisan terakhir berjumlah 4 ranup, berapa total*

Before Revision	After Revision
mereka susun agar hiasan sempurna? Berapa pula jumlah ranup yang diperlukan untuk membuat ranup hiasan tersebut? **Translated:** If the number of *ranup* in the second layer is two less than in the first layer, and the last layer contains four *ranup*, how many total layers of *ranup* do they need to arrange for a perfect decoration? Moreover, how many *ranup* are needed in total to create the decoration?	*lapisan ranup yang diperlukan untuk menyusun hiasan tersebut? Berapa pula jumlah ranup yang diperlukan secara keseluruhan?* **Translated:** If the number of *ranup* in the second and subsequent layers decreases by two compared to the previous layer, and the last layer contains four *ranup*, how many total layers of *ranup* are needed to arrange the decoration? Moreover, how many *ranup* are needed in total?

After the revision was made, developmental testing was conducted in three phases: a one-to-one evaluation, a small-group trial, and a field test.

One-to-one evaluation. A one-to-one evaluation involved three students who were asked to solve problems to check the readability and clarity. The problems were subsequently revised based on the suggestions from students. The problems were revised in terms of wording only to enhance clarity. The revisions made based on students' feedback are presented in Table 7.

Table 7. Revision for question 10 based on students' feedback

Before Revision	After Revision
Jika yang melakukan peusijuk pertama adalah teungku, yang kedua dan ketiga adalah ayah dan ibu. Selanjutnya diikuti oleh yang lainnya. Maka, ada berapa cara yang dapat dilakukan MC untuk menyusun daftar urutan nama yang akan melakukan peusijuk tersebut? **Translated:** Suppose the first person performing the peusijuk is teungku, the second and third are father and mother, and the rest follow afterwards. How many possible ways are there for the MC to arrange the list of names of those who will perform the *peusijuk*?	*Jika orang yang melakukan peusijuk pertama adalah teungku, yang kedua dan ketiga berturut-turut adalah ayah dan ibu. Selanjutnya, diikuti oleh keluarga lainnya. Maka, ada berapa cara yang dapat dilakukan MC untuk menyusun daftar urutan nama yang akan melakukan peusijuk tersebut?* **Translated:** If the first person performing the *peusijuk* is *teungku*, the second and third are father and mother, respectively, followed by the other family members. How many possible ways can the MC arrange the list of names of those who will perform the *peusijuk*?

Small group trial. Then, in the small group trial, the problems were administered to six students. They were requested to solve the problems and complete the questionnaire to assess the practicality of the problems. They were also requested to provide written comments and suggestions regarding the problems. van den Akker et al. (2006) state that the practicality of a product is indicated by its ease of use and applicability in the classroom settings. The product is practical if the percentage of practicality value is

greater than 59% as listed in Table 8 (Dahal et al., 2023). The results of the questionnaire are shown in Table 9.

Table 8. The practicality criteria (dahal et al., 2023)

Score Percentage	Practicality Criteria
82% - 100%	Very practical
71% - 81%	Practical
66% - 70%	Pretty Practical
60% - 65%	Little Practical
0-59%	Not Practical

Table 9. The practicality of problems

Statement	Percentage
The problems align with the topic I have studied (S1)	100%
The problems use language that is clear and easy for me to understand (S2)	75%
The problems are not ambiguous (S3)	67%
The texts and images are clearly visible (S4)	96%
The instructions for implementing the questions are clear and easy for me to understand (S5)	83%
The information contained in the questions can increase my knowledge about culture	100%
The problem helps me to understand mathematical concepts (S6)	100%
Average	**89%**

The result revealed that the practicality of the problems is 89%, indicating that the problems are considered highly practical for use in the classroom. The lowest percentage is 67%, corresponding to the statement "the problems are not ambiguous" (S3). Then, the second lowest (75%) refers to the statement "The problems use language that is clear and easy for me to understand" (S2). These two statements align with the language aspect (ambiguity, clarity, readability) in the expert validation, which receives the lowest score compared to other aspects. This may contribute to the lowest score in S3. The incorporation of cultural context in the problems does not generate ambiguity; nevertheless, several students encountered difficulties in solving them due to their limited familiarity with contextualized problems and extended reading passages. Moreover, some items necessitated analysis and reasoning based on the reading passages. Despite these challenges, such problems are valuable in developing students' literacy and fostering their reading habits and accuracy. Therefore, although practical, revisions to the problems are still needed in response to the comments and feedback provided by students. The aspect revised primarily concerns the clarity of language in the reading text, addressing issues that prevent problems from being interpreted in multiple ways. After being revised, the problems were advanced to the field-testing stage.

Field Test

In the field test, the products were administered to 32 students. Students' answers were evaluated based on the mathematical literacy rubric. The analysis at this stage examined the validity and effectiveness of the problems. The validity was analyzed using Pearson's product-moment correlation at the 5% significance level. The test yielded a

correlation coefficient of 0.93, which reflects a very high degree of validity. The analysis revealed that 19 problems were found to be valid, while one was identified as invalid. The invalid item requires students to generalize from a sequence of items. Most students were unable to solve the problem and perceived it as challenging. This suggests that the cognitive demand of the problem exceeded the students' current level, thereby reducing its validity for the targeted student level. The results of the validity of each item are presented in Table 10.

Table 10. Item validity result

Item	Correlation	Significance	Interpretation
1	0.620	Very significant	Valid
2	0.068	-	Invalid
3	0.406	Significant	Valid
4	0.429	Significant	Valid
5	0.626	Very significant	Valid
6	0.469	Significant	Valid
7	0.586	Very significant	Valid
8	0.599	Very significant	Valid
9	0.461	Significant	Valid
10	0.719	Very significant	Valid
11	0.639	Very significant	Valid
12	0.579	Very significant	Valid
13	0.674	Very significant	Valid
14	0.648	Very significant	Valid
15	0.635	Very significant	Valid
16	0.819	Very significant	Valid
17	0.894	Very significant	Valid
18	0.819	Very significant	Valid
19	0.584	Very significant	Valid
20	0.812	Very significant	Valid

Besides that, the effectiveness of the problems is indicated by the average score from the field test, which should meet at least the 'fairly good' criterion, defined as a score between 50 and 75 (Ajizah et al.,2023). Although this study conducted a single field test, students' average score in this field test may not provide a robust evaluation of effectiveness; however, it can serve as an initial indication of effectiveness. The results revealed that the student average score in the field test is 67.66, falling within the 'fairly good' criteria. However, more than half of the total students (56.25%) achieved scores between 50 and 75, which is considered fairly good; meanwhile, 37.5% of students attained scores that met the good criteria. These findings suggest that the developed problems may have the potential to enhance students' mathematical literacy. When compared with the school's minimum criteria score of 75, the average score of 67.66 falls below the expected standard. This outcome is not surprising, as students had not previously been exposed to mathematical literacy tasks integrating cultural contexts. Bolstad (2023) It was also found that students had insufficient encounters with mathematics that involved social and cultural issues. Instead, they were predominantly accustomed to routine problems. Students are likely to achieve a better understanding of

mathematical literacy when they can recognize mathematics embedded within contextual problems and engage in the process of mathematizing these contexts. One of the students stated, "The reading and the context help me to understand the problems, but, for some problems, I do not know how to solve them." Another student expressed, "Actually, the problem will be easy if I know how to change them into a mathematical form." This challenge is commonly encountered by students due to insufficient comprehension, particularly of the wording in problem texts (Hajida & De La Cruz, 2022; Kolar & Hodnik, 2021). This aspect is crucial, as the text serves not only to convey information but also to frame the interpretation of mathematics in contextual situations. The students' scores in the field test are depicted in Figure 6.

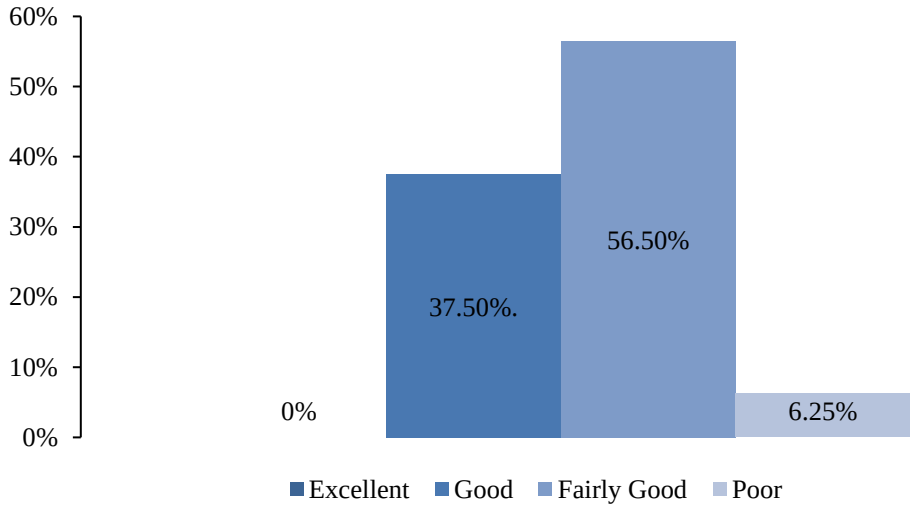


Figure 6. Students' scores in the field test

Referring to the mathematical literacy indicators, students achieved an average score of 85.71 in the aspect of problem formulation, indicating that their ability in this domain can be classified as good. In contrast, the average scores for employing mathematical procedure culture-based instruction, as reflected in mathematical results (57.58), fall within the category of fairly good. This finding is consistent with the tendency that students generally demonstrate stronger skills in problem formulation compared to interpretation. The interpretation process inherently demands higher-order thinking skills, which may explain the relatively lower performance in this aspect. Figure 7 describes the students' average scores in mathematical literacy indicators.

According to the analysis, this current study produced 19 valid mathematical literacy problems in the context of Acehnese culture. It also demonstrates the practicality and effectiveness of the problems. The problems are feasible after going through several evaluations and revisions. The validation process, which consisted of expert evaluations, one-on-one evaluations, small-group evaluations, iterative revisions, and field testing, confirmed that these problems meet established validity criteria and are viable for use in classroom instruction. The problems' practicality was a critical factor, serving as a benchmark for usability and potential impact on student learning (Serevina, Sunaryo, Raihanati, Astra, & Sari, 2018). The validity and practicality of the problems suggest that

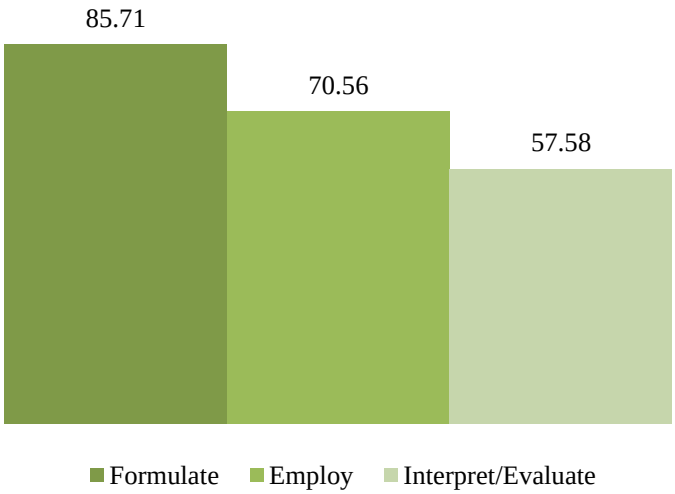


Figure 7. Students' average score in mathematical literacy indicators

they are not only theoretically sound but also practically useful for teachers who intend to apply culture-based instruction. The effectiveness of the problems, as demonstrated by their successful implementation during field testing, confirms that they are potentially applicable in real classroom settings. However, the presence of one invalid item indicates areas for further improvement. The item's level of cognitive challenge exceeded the students' capabilities, thus limiting the appropriateness of the problem for the targeted learners. Mathematical literacy can be fostered through suitable scaffolding aligned with the levels of mathematical tasks (Hwang & Ham, 2021). As such, this item requires re-examination to ensure the cognitive demand is suitable for the targeted students' level.

The emphasis on cultural relevance addresses a growing need in education to make learning more inclusive and equitable. The significance of embedding Acehnese culture in mathematical literacy problems also aligns with the principles of the most recent Indonesian curriculum, which advocates for integrating students' cultural contexts into mathematics learning. Many students struggle to see the relevance of mathematics in their daily lives (Fitzmaurice et al., 2021), which can diminish motivation and mathematics achievement. By contextualizing problems within the Acehnese cultural context, this study not only validates the students' cultural identity but also demonstrates the practical application of mathematics beyond classrooms. Meaney, Trinick, & Allen (2021) and Batiibwe (2024) They also argue that incorporating ethnomathematics into the mathematics classroom is an effective way to create meaningful and relevant learning experiences in mathematics for students.

Furthermore, the result of the current study revealed that students agree that the problems contextualized in Acehnese culture help them to understand mathematical concepts. Encouraging students to analyze and interpret mathematical situations through the lens of their own cultural knowledge allows them to enhance their mathematical literacy (Pratama & Yelken, 2024), critical thinking, and problem-solving skills (Toheri, Winarso, & Haqq, 2020; Yang, 2024). Mathematical literacy can be fostered by encountering different mathematical problems in different contexts (Hwang & Ham, 2021). Incorporating aspects of culture in mathematics problems provides meaningful connections between abstract mathematical concepts and students' lived experiences

(Acharya, Kshetree, Khanal, Panthi, & Belbase, 2021). Such connections can foster more profound understanding and engagement, as students are more likely to relate to problems that reflect their social and cultural experiences (Acharya et al., 2021). Integrating local culture into teaching and learning also increases student interest and participation (Acharya et al., 2021).

In response to the cultural integration in teaching, teachers must possess cultural competency to ensure that cultural elements enrich essential mathematical skills (Kolovou, 2023), foster cultural awareness (Zhang & Tian, 2025), and understand students' needs (Ellis-Robinson & Coles, 2021). However, the culture integration present challenges, particularly in connecting mathematical content with cultural contexts (Kolovou, 2023). Therefore, relevant cultural mathematics resources are critical for teachers. The development of these problems provides a valuable resource for mathematics teachers in Aceh. It also raises their awareness of local cultures and equips them with strategies to design more culturally responsive mathematics instruction. This localized approach can serve as a model for curriculum developers aiming to create culturally responsive learning materials. The findings of this study suggest guidance for teachers in developing culturally mathematical literacy problems. First, teachers select authentic local cultural practices or elements that are familiar to students to foster engagement and understanding. Then, teachers ensure the alignment of the context with the curriculum, such as the topics being studied and the learning objectives. The problems being developed should also be suitable for the students' level. They focused on mathematical literacy development. Good problems will allow students to have productive struggle. Teachers then write the problems using clear and accessible language so that students can understand them. After problems were designed, iterative trials and revisions were conducted. This step includes validation by experts.

Nevertheless, this study has limitations that should be acknowledged. The field test involved a relatively small sample of students, which may limit the generalizability of the findings. Future research should consider larger and more diverse samples to validate the effectiveness of these interventions across different student populations. Additionally, while this study focused on a few mathematical topics at the senior high school level, integrating broader topics could further enrich the cultural mathematics resources for teachers and students. This study recommends that future studies develop mathematical literacy problems on different mathematical topics and in different Acehnese contexts. It is also valuable to explore the long-term effects of using culturally based mathematical problems on students' achievement, attitudes, and identity. Longitudinal studies could provide insights into how sustained exposure to ethnomathematics influences students' learning trajectories and their perception of mathematics as a meaningful and accessible subject.

▪ CONCLUSION

The current study aims to design mathematical literacy problems that are grounded in the ethnomathematics of Acehnese culture, ensuring they are valid, practical, and effective for classroom use. The findings demonstrated a high level of validity, as indicated by a strong correlation coefficient of 0.93. Out of the 20 developed problems, 19 were found to be valid based on expert judgment and empirical analysis, while one was categorized as invalid and subsequently excluded from the final product. The

practicality of the problems was affirmed through student evaluation, which yielded an average score of 89%, suggesting that the problems are feasible and viable for classroom implementation. In terms of effectiveness, the problems showed promising results in improving students' mathematical literacy, as evidenced by an average score of 67.66. This score falls within the 'fairly good' category, indicating that the problems not only align with curriculum goals but also have the potential to positively impact students' mathematical understanding and mathematics literacy ability.

The results of this study underscore the potential of ethnomathematics to make mathematics learning more inclusive, culturally relevant, and equitable. By integrating local cultural elements into mathematics problem design, students are more likely to engage with mathematics in meaningful ways that reflect their daily experiences and heritage. This culturally responsive approach may foster more profound understanding and appreciation of mathematics among learners. However, this study has several limitations, including a small sample size and a less rigorous design for evaluating product effectiveness. These limitations open opportunities for future research to employ larger samples and more robust designs to further assess the ethnomathematics-based mathematical literacy problems developed in the study. It is also recommended that future research expand upon this work by developing mathematical literacy problems across a broader range of mathematical topics and within other cultural contexts of Aceh. Moreover, investigating the long-term impacts of using ethnomathematics-based problems, particularly regarding student achievement, attitudes toward mathematics, and the development of mathematical identity, could provide further insight into the transformative potential of this approach. Finally, integrating ethnomathematics into classroom practice can foster meaningful learning experiences, while also supporting the government's goals of the National Literacy Movement to strengthen students' literacy competencies at the national scale.

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