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Development of an Open-ended Numeracy Literacy Instrument: Context of Timorese Culture

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ABSTRACT
Addressing complex problems requires multiple and sustainable solution strategies, highlighting the importance of students' numeracy literacy. However, existing assessment practices often fail to capture students' higher-order thinking and problem-solving flexibility, particularly in algebraic contexts. An open-ended, locally wisdom–based instrument is considered appropriate for fostering students' problem-solving abilities; however, it is rarely implemented in regular classroom instruction. Furthermore, research on the development of open-ended numeracy literacy instruments within Timorese culture remains limited. This study aims to develop and validate an open-ended numeracy literacy instrument in the algebra domain to address this gap. The study employed a design-based development approach using Tessmer's formative evaluation, which includes preliminary study, expert review, one-to-one, small-group, and field-test stages. Qualitative data were obtained from expert validation, student feedback, and interviews, while quantitative data were collected through student response questionnaires and test results. The findings reveal that the developed instrument meets the criteria of validity, practicality, and reliability. Furthermore, the instrument demonstrates moderate difficulty and acceptable discrimination, indicating its effectiveness in distinguishing students' abilities. This study contributes a valid and reliable open-ended assessment tool that can support the enhancement of students' numeracy literacy and promote meaningful mathematics learning in algebra.
Keywords: Instrument, Numeracy, Open-ended, Tessmer, Validation

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Introduction

Individuals must possess sound thinking and judgment to make precise decisions. This necessity arises because real-world problems are inherently complex. Such complexity often demands solutions that are not singular, but may involve multiple alternatives or even continuous actions (Lina et al., 2025; Lafuente-Lechuga et al., 2020). Therefore, individuals need to refine their understanding and reasoning to determine effective solutions to real-life problems.

One way to develop a strong understanding and reasoning is through engaging with instruments that challenge individuals to explore solutions and test their cognitive abilities. Numeracy literacy plays a crucial role in accommodating these cognitive levels, particularly in fostering understanding and reasoning. These competencies can be further enhanced when students are exposed to complex problems presented in

open-ended forms, which require not only understanding and reasoning but also creativity (Salsabila et al., 2025; Rahayuningsih et al., 2021).

Open-ended tasks are effective for students because they produce diverse outcomes that reflect varying levels of achievement (Bayarcal & Tan, 2023; Henriksen et al., 2021). This is due to their ability to stimulate students' thinking styles and reasoning skills when addressing a given problem. Consequently, students' responses represent diverse levels of reasoning and creativity. Furthermore, to habituate students to real-world problem-solving, learning should integrate contexts that are closely related to daily life from an early stage. The algebra domain—including number patterns, linear equations and inequalities, and ratios and proportions—is widely encountered in everyday situations.

Daily life is inseparable from cultural elements, including Timorese culture. Culture constitutes an integral part of human civilization and reflects the application of mathematics in various forms, such as classifying, counting, measuring, designing structures or tools, and engaging in games (Kurniawan et al., 2024; Abdullah, 2017; D'Ambrosio, 1985). The incorporation of cultural aspects is considered an effective approach to enhancing the relevance of formal mathematics learning and increasing students' engagement (Leton et al., 2025; Agusdianita et al., 2025; Leton et al., 2023). In this regard, integrating culture into mathematics learning, particularly through assessment instruments, can foster students' problem-solving skills.

Students' numeracy literacy can be effectively developed through local cultural contexts. (Simamora et al., 2023) found that students perform better at solving mathematical problems when the tasks are presented in familiar, culturally relevant contexts. This supports the notion that embedding numeracy literacy within local cultural contexts can strengthen students' problem-solving abilities through more meaningful and contextualized learning experiences (Leton et al., 2026).

Despite these contributions, research on the development of open-ended numeracy literacy instruments remains limited. In fact, because numeracy literacy aims to support individuals in generating solutions to real-world problems, limiting responses to a single correct answer may limit students' understanding and reasoning. In reality, many real-life problems involve multiple variables and potentially unlimited solution pathways (Bingölbali et al., 2021). Therefore, this study seeks to develop a valid, reliable, and practical open-ended numeracy literacy instrument in the algebra domain, grounded in Timorese cultural contexts, to strengthen students' numeracy literacy through meaningful assessment practices.

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Methods

Research Design

This study employed a development research design consisting of two main phases: the preliminary study and the formative evaluation phase, as proposed by Tessmer (Tessmer, 2013). The formative evaluation included self-evaluation, prototyping (including expert reviews, one-to-one evaluation, and small-group evaluation), and a field test.

Participants

The study was conducted during the first semester of the 2025/2026 academic year. It involved three expert validators and 30 students from a junior high school in North Central Timor Regency, East Nusa Tenggara, Indonesia.

Procedure

The research procedures are described in Table 1.

Table 1. Description of the Stages in Development Research

Stage	Description	Outcomes
Preliminary Study	Identifying students' needs regarding learning resources, learning experiences, and the Timorese cultural context to be incorporated into the developed instrument, and conducting the initial design of the instrument.	The results of the observations concern learning resources, students' learning experiences in the algebra domain, the Timorese cultural context incorporated into the instrument, and the instrument format.
Formative Evaluation a. Self-evaluation	Developing and reviewing the instrument blueprint, item answer keys, scoring guidelines, and the levels of numeracy literacy competence based on score intervals.	Prototype-1: Open-ended numeracy literacy items based on the Timorese cultural context, along with the instrument blueprint, answer keys, and scoring guidelines that have been self-reviewed.
b. Expert review and One-to-one	Prototype-1 was distributed to three experts for a feasibility evaluation of language, construct, and content. Simultaneously, Prototype-1 was administered to three students with varying levels of mathematical ability,	i. The results of the validation analysis from three experts. ii. The results of the response questionnaires from three students. iii. Following revisions based on the results in (i) and (ii), Prototype-2 was produced, consisting of open-ended numeracy literacy items

Stage	Description	Outcomes
	followed by interviews conducted after they completed the tasks.	grounded in the Timorese cultural context, along with the revised instrument blueprint, answer keys, and scoring guidelines.
c. Small group	Prototype-2 will be administered to seven students who have studied the relevant material to examine their responses to the product's use as an indication of the practicality of the developed items.	After revisions based on students' response sheets, Prototype-3 was produced, consisting of open-ended numeracy literacy items grounded in the Timorese cultural context that are both valid and practical.
d. Field test	Prototype-3 was administered to 30 students studying the relevant material to determine the items' level of difficulty, discrimination index, and reliability.	Open-ended numeracy literacy items based on the Timorese cultural context that are valid, practical, and reliable.

Instruments

The instruments used, including the validator sheet, would be spread for three validators who are experts in numeracy literacy instrument development, evaluation, and measurement. A questionnaire for students' responses to the instruments was then used. In addition, an observation sheet for identifying students' needs and the self-evaluation stage.

Data Collection and Data Analysis

The data collection techniques included documentation, observation, expert validation sheets, student response questionnaires, and interviews. The data analysis techniques employed were both qualitative and quantitative. Qualitative analysis was conducted on data derived from experts' suggestions and comments. In contrast, quantitative analysis was applied to students' responses and test scores to determine the reliability, item difficulty, and discrimination power of the items. For the practicality test conducted during the small-group stage, the average score from the student response questionnaires was calculated using the following Formula 1:

$$\bar{M}_p = \frac{\sum_{i=1}^{n} \bar{P}_i}{n} \qquad (1)$$

Note:

$\bar{M}_p$= average of product practicality

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$\bar{P}_i$ = the i-th student's score average
n = the number of assessed aspects

After performing the above calculations, the product's practicality category can be determined using Table 2.

Table 2. Justification of Product Practicality

Score Interval	Practical Category
$4 \leq \bar{M}_p \leq 5$	Highly practical
$3 \leq \bar{M}_p < 4$	Practical
$2 \leq \bar{M}_p < 3$	Less practical
$1 \leq \bar{M}_p < 2$	Not practical

The open-ended numeracy literacy items based on the Timorese cultural context are considered practical if the calculated score from the student response questionnaires falls within at least $3 \leq \bar{M}_p < 4$. At the field test stage, the reliability, item difficulty, and discrimination index of the developed instrument will be analyzed using students' test results and their responses to the instrument. Table 3 shows the justification for instrument reliability.

Table 3. Justification of Instrument Reliability

Score Interval	Reliability Criteria
$r_{11} \leq 0{,}20$	Very low
$0{,}20 \leq r_{11} < 0{,}40$	Low
$0{,}40 \leq r_{11} < 0{,}70$	Moderate
$0{,}70 \leq r_{11} < 0{,}90$	High
$0{,}90 \leq r_{11} < 1{,}00$	Very hight

Subsequently, the instrument's difficulty level needs to be determined. This is intended to ensure that the items align with the abilities of students at Level 4 or in Grade 8. Table 4 justifies the difficulty level.

Table 4. Justification of Difficulty Level

Score Interval	Difficulty Classification
$Dl \leq 0{,}30$	Difficult
$0{,}30 \leq DL \leq 0{,}70$	Moderate
$Dl > 0{,}70$	Easy

This is followed by identifying the discrimination index of the items (Table 5) to facilitate differentiation of students' abilities in solving the tasks, as reflected in the variability of their results.

Table 5. Justification Discrimination Index

Score Interval	Discrimination Index Criteria
$DP \leq 0{,}20$	Poor
$0{,}20 \leq DP \leq 0{,}40$	Moderate
$0{,}40 \leq DP \leq 1{,}00$	Good

After determining the instrument's reliability, item difficulty level, and discrimination index at the field-testing stage, the instrument is evaluated to assess the feasibility of the developed items for classroom mathematics instruction.

Result and Discussions

This section presents the results of the development of open-ended numeracy literacy items based on Tessmer's procedure.

Preliminary Study

Identifying students' learning needs

Students' numeracy literacy skills have not yet reached an optimal level, as indicated by the substantial gap observed in students' AKM (national assessment) results. Based on field conditions, it was found that the strengthening of numeracy literacy through assessment has not been implemented optimally. The items completed by students across topics remain largely routine in nature and do not guide students to explore multiple solution strategies. As a result, students are limited in their ability to explore diverse problem-solving approaches. Furthermore, the textbooks and learning resources used have not incorporated local cultural contexts. Such contexts are essential for stimulating students' thinking and enabling them to identify and solve problems encountered in their daily lives. Therefore, it is important to train students through providing the proper assessment (Ladyawati & Maftuh, 2025).

Determining the Timorese cultural context to be integrated into the instrument

Timorese culture can be identified into seven categories in relation to its integration into mathematics learning: motifs produced from weaving activities; traditional houses, such as *lopo* and *ume kbubu*; traditional foods, such as *laku tobe*, *bose*, *sambal lu'at*, and *jagung katemak*; traditional dances or customary ceremonies, such as *usapena*, *bonet*, *tebe*, and *bidu*; handicrafts or woven products, such as *oko* (a rice container made from *gewang* leaves), baskets, betel nut containers, and *nyiru*; traditional musical instruments, such as the Timorese gong; and folklore (Disnawati & Nahak, 2019).

Furthermore, the researcher integrated Timorese cultural contexts into the algebra subdomains. Based on a review of relevant literature, weaving motifs are associated with number patterns that involve key components such as differences and ratios. For

the topic of linear equations, traditional Timorese houses—*lopo* and *ume kbubu*—were utilized to model the materials required in a system of linear equations in two variables. Meanwhile, the *Usapena* traditional ceremony was selected for integration into the topic of ratio and proportion, as it involves quantities of food prepared according to specific ratios and proportions. Furthermore, the traditional gong was incorporated into the topic of systems of linear inequalities, specifically regarding the minimum capital required for its production.

Designing a numeracy literacy instrument - algebra domain

At this stage, the researcher designed the instrument by formulating the instrument blueprint, as presented in Table 6, which was developed based on the guidelines from (Wiedarti, 2016). The instrument developed consists of numeracy literacy items encompassing four subdomains of algebra and is presented in an open-ended format. Furthermore, the instrument is designed to guide students in generating multiple alternative solutions.

Table 6. Blueprint of Open-Ended Numeracy Literacy Instruments Based on the Timorese Cultural Context

Item	Sub-domain	Cognitive Level	Competency	Form of item
1	Pattern of number	**Understanding:** Identifying patterns over a given period and generalizing number sequence patterns into a formula.	Generalizing patterns in number sequences and object configurations.	Open-ended
2	Linear equation	**Implementation:** Using relationships among numbers and quantities to satisfy a given equation	Solving a system of linear equations in two variables.	Open-ended
3	Ratio and portion	**Reasoning**: Connecting multiple pieces of information to solve a problem.	Solving social arithmetic problems related to ratios and percentages.	Open-ended
4	Linear equality	**Implementation**: Using relationships among numbers and quantities to satisfy a given inequality.	Solving a system of linear inequalities in two variables.	Open-ended

Formative Evaluation

Self-evaluation

At this stage, the researcher conducted a self-evaluation of the instrument design developed during the preliminary study. The researcher re-examined whether the developed instrument adequately accommodated all algebra content, cognitive process domains, open-ended question formats, and the local cultural context in Timor-Leste. In addition, the prepared alternative answers were designed to capture various students' ways of thinking. This stage resulted in Prototype-1, which consists of the instrument blueprint, open-ended numeracy-literacy items grounded in the Timorese cultural context, and alternative solutions to the problems.

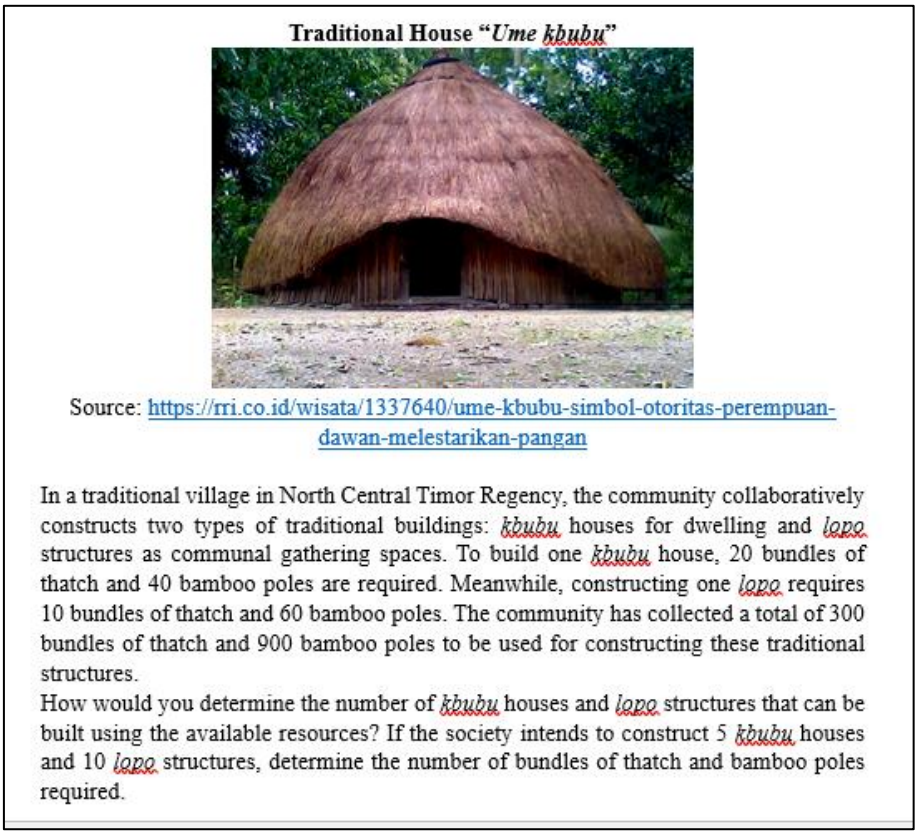

Figure 1. Instrument Item 2 Prototype-1 before self-evaluation

In Item 1, a problem related to number patterns is presented in the context of Timorese weaving motifs. After review, the researcher determined that Item 1 did not require any revision. In item 2, as shown in Figure 1, a problem on systems of linear equations in two variables (SPLETV) is presented within the context of traditional Timorese houses. After review, the researcher determined that item 2 required revision, specifically by presenting the narrative of the required materials for the traditional house in tabular form. This was intended to guide students in interpreting information

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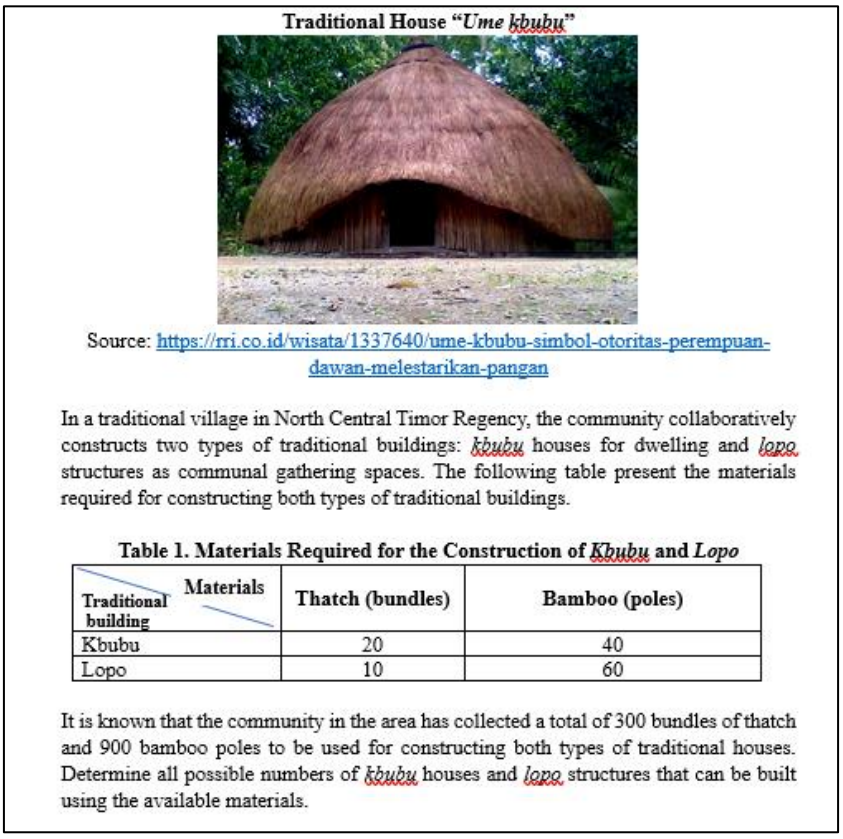
presented in tabular form as part of numeracy literacy competencies. Figure 2 shows item 2 after revision based on validator input.



Traditional House "*Ume kbubu*"

Source: https://rri.co.id/wisata/1337640/ume-kbubu-simbol-otoritas-perempuan-dawan-melestarikan-pangan

In a traditional village in North Central Timor Regency, the community collaboratively constructs two types of traditional buildings: *kbubu* houses for dwelling and *lopo* structures as communal gathering spaces. The following table present the materials required for constructing both types of traditional buildings.

Table 1. Materials Required for the Construction of *Kbubu* and *Lopo*

Traditional building \ Materials	Thatch (bundles)	Bamboo (poles)
Kbubu	20	40
Lopo	10	60

It is known that the community in the area has collected a total of 300 bundles of thatch and 900 bamboo poles to be used for constructing both types of traditional houses. Determine all possible numbers of *kbubu* houses and *lopo* structures that can be built using the available materials.

Figure 2. Instrument Item 2 Prototype-1 after self-evaluation

Furthermore, instrument item 3 underwent revisions following the self-evaluation stage. The modifications pertained to the problem context within the topic of ratio and proportion and were subsequently aligned with students' cognitive level at Level 4. Previously, comparisons of food portions were associated with potentially varying numbers of participants. After the self-evaluation process, the problem information was simplified by relating it to the average weight of the food ingredients.

In Item 4, which addresses linear inequalities, the problem requires students to determine the possible combinations of large and small Timorese traditional gongs within a limited budget. After reviewing the item, the researcher concluded that no revisions were necessary. Table 7 presents the results of the self-evaluation.

Table 7. Summary of Self-evaluation result

Instrumen	Before self-evaluation	After self-evaluation
Item 1	The problem related to number patterns is presented in the context of Timorese weaving motifs	There is no need for revision.

Instrumen	Before self-evaluation	After self-evaluation
Item 2	The problem of systems of linear equations in two variables (SPLDV) is presented within the context of traditional Timorese houses.	This item required revision, specifically by presenting the narrative of the required materials for the traditional house in tabular form.
Item 3	The comparisons of food portions were associated with potentially varying numbers of participants.	The problem information was simplified by relating it to the average weight of the food ingredients.
Item 4	The problem requires students to determine the possible combinations of large and small Timorese traditional gongs within a limited budget.	There is no need revision.

Expert review and One-to-one

The expert review and one-to-one stages were conducted in parallel. During the expert review, Prototype-1 was validated by three experts specializing in ethnomathematics, algebra instruction, and mathematics assessment. Meanwhile, the one-to-one stage involved three grade 9 students who had studied the relevant material to examine the clarity of the instrument's information and its ease of understanding for students. The suggestions and comments from the validators are presented in Table 8.

Table 8. Summary of Suggestions and Comments from the Validators

Instrument	Validator 1	Validator 2	Validator 3
Item 1	-	-	Woven products typically include mats, betel nut containers, and rice sieves. In Timorese culture, fabrics are traditionally produced through weaving.
Item 2	Attention should be paid to the consistency of the font type and font size in the table. Consistency of units: compare the information presented in the table and the narrative, specifically regarding "900 bamboo rods" or "bundles of bamboo."	The term *ikat* (tie) on the bamboo should be replaced with *batang* (rod). -	Gunakan mode *italic* untuk bahasa/istilah daerah The commonly used unit for bamboo is "rods" (*batang*), not "bundles" (*ikat*).

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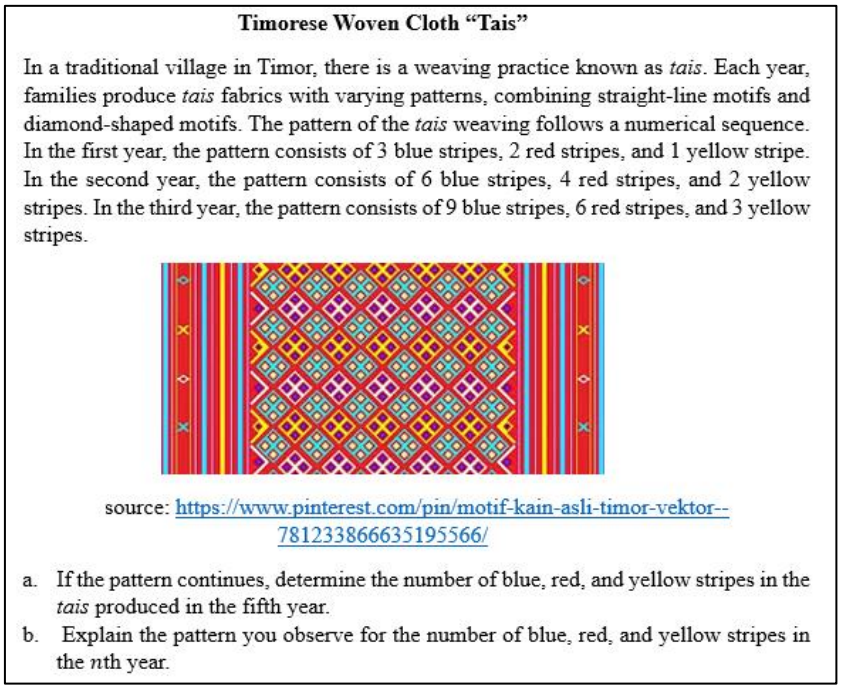
Instrument	Validator 1	Validator 2	Validator 3
	Which region is being referred to? The data in Table 1 above does not explicitly specify a particular region; therefore, the phrase "that region" in this information is ambiguous. It would be better to explicitly mention one specific region where the traditional building is located.	-	The concluding statement of the sentence can be revised as follows: "Determine all possible combinations of ume kbubu (traditional houses) and lopo that can be built without exceeding the total available materials."
Item 3	"More" does not necessarily mean "heavier"; this aspect needs clarification.	-	The stimulus title should be adjusted or shortened so that it does not exceed the image. It is also necessary to anticipate students who may misinterpret the problem as $j > b + k$.

The results of the expert validation indicated that the developed instrument is valid in terms of content, construct, and language. Subsequently, suggestions and comments from students in the one-to-one stage for Item 3 indicated that the conditional statements should be presented in a list format to avoid misinterpretation, and that the term "Usa pena" should be corrected to "Usapena." The instrument was then revised based on the recommendations and feedback from both experts and students, ensuring alignment with the intended objectives.



Timorese Woven Cloth "Tais"

In a traditional village in Timor, there is a weaving practice known as *tais*. Each year, families produce *tais* fabrics with varying patterns, combining straight-line motifs and diamond-shaped motifs. The pattern of the *tais* weaving follows a numerical sequence. In the first year, the pattern consists of 3 blue stripes, 2 red stripes, and 1 yellow stripe. In the second year, the pattern consists of 6 blue stripes, 4 red stripes, and 2 yellow stripes. In the third year, the pattern consists of 9 blue stripes, 6 red stripes, and 3 yellow stripes.

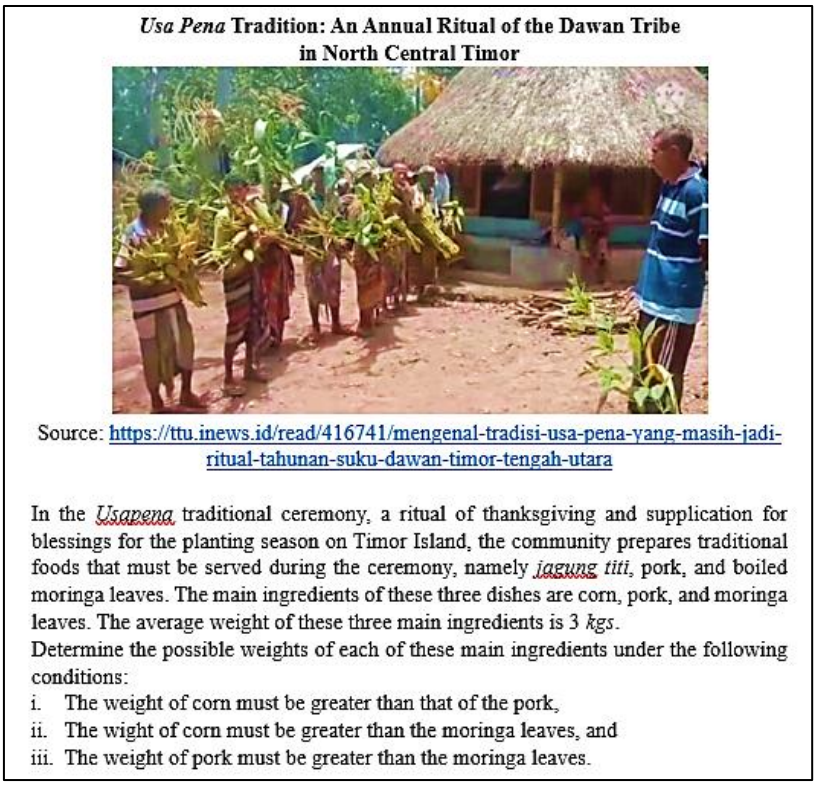
source: https://www.pinterest.com/pin/motif-kain-asli-timor-vektor--781233866635195566/

a. If the pattern continues, determine the number of blue, red, and yellow stripes in the *tais* produced in the fifth year.
b. Explain the pattern you observe for the number of blue, red, and yellow stripes in the nth year.

Figure 3. Instrument Item 1 Prototype-1 after revision

The revisions for Item 1 (Figure 3) included replacing the term "woven fabric" (*anyaman kain*) with "woven cloth" (*kain tenun*). For Item 2, the font type in the table was standardized due to inconsistencies between the table and the narrative. Additionally, the unit for bamboo was changed from "bundles" (*ikat*) to "rods" (*batang*). The region was also specified as Oenenu Village, and finally, the instructional statement leading to the question was revised to be more concise and efficient.

Revisions to item 3 (Figure 4) included replacing the word "many" with "weight," as "many" does not necessarily correspond to weight. The title of the problem context was also adjusted or shortened. Furthermore, the conditions in Item 3 were clarified to state that the corn must be heavier than the pork and the moringa leaves, and these conditions were presented in a bullet-point format. Meanwhile, Item 4 was not revised.


***Usa Pena* Tradition: An Annual Ritual of the Dawan Tribe in North Central Timor**

Source: https://ttu.inews.id/read/416741/mengenal-tradisi-usa-pena-yang-masih-jadi-ritual-tahunan-suku-dawan-timor-tengah-utara

In the *Usapena* traditional ceremony, a ritual of thanksgiving and supplication for blessings for the planting season on Timor Island, the community prepares traditional foods that must be served during the ceremony, namely *jagung titi*, pork, and boiled moringa leaves. The main ingredients of these three dishes are corn, pork, and moringa leaves. The average weight of these three main ingredients is 3 *kgs*.
Determine the possible weights of each of these main ingredients under the following conditions:

i. The weight of corn must be greater than that of the pork,
ii. The wight of corn must be greater than the moringa leaves, and
iii. The weight of pork must be greater than the moringa leaves.

Figure 4. Instrument item 3 Prototype-1 after revision

The revised instrument represents Prototype-2, which will be used in the subsequent stage.

Small group

At this stage, Prototype-2 was tested on a small group consisting of seven students. The researcher examined students' responses to numeracy literacy problems to

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determine whether they contained errors or misunderstandings. The summary of students' responses to Prototype-2 is presented in Table 9.

Table 9. Summary of Students' Responses to Prototype-2

Instrument	Findings
Item 1	Students were able to identify the pattern in the number of lines for the fourth and fifth terms; however, they were unable to generalize the pattern into a formula for the n-th term.
Item 2	Students proposed several possible combinations of the numbers of *kbubu* and *lopo* houses that could be constructed; however, some students provided only a single solution.
Item 3	Students determined the portions of corn, pork, and moringa leaves so that the total weight of the three ingredients was 3 kg, whereas others reported *a total weight of 9 kg*.
Item 4	Students provided single responses, with considerable variation observed across individuals.

The student response questionnaire was then administered to assess the instrument's practicality. Based on the questionnaire results, the developed items were categorized as highly practical. Students found the items somewhat difficult because they were not accustomed to this type of question and did not fully understand the concept of the nth term. Based on students' responses and the questionnaire results, no significant revisions were made. The students' responses were considered as a new learning experience with the developed instrument. Following this stage, the instrument was designated as Prototype 3.

Field test

At this stage, Prototype-3 was administered to 30 students to assess its reliability, discrimination index, and difficulty level. The results of the field test interpretation are presented in Table 10.

Table 10. Criteria of Reliability, Discrimination Index, and Difficulty Level of Prototype 3

Instrument item	Reliability Score	Reliability Criteria	Difficulty Score	Difficulty Level	Discrimination Index Score	Discrimination index
1	0,73	High	0,543	Moderate	0,277	Moderate
2			0,481	Moderate	0,230	Moderate
3			0,488	Moderate	0,338	Moderate
4			0,562	Moderate	0,372	Moderate

The instrument was developed and revised based on self-evaluation results and recommendations from both validators and students at each stage, while ensuring alignment with its intended objectives. The validity criteria were established based on

the validators' responses regarding the formulation of the instrument, such as the blueprint and alternative solutions to open-ended problems, as well as the scoring rubric aligned with numeracy literacy indicators. Each item in the instrument accommodates various students' ways of thinking in solving the presented problems. It means the instrument items meet appropriateness in content, structure, and clarity (Hapsari et al., 2025). This approach aligns with the criteria for open-ended responses developed through this instrument, which provides students with opportunities to generate multiple solution strategies (Isyrofinnisak et al., 2020). The validation process is essential to justify that the developed instrument is capable of measuring students' numeracy literacy skills (Randy et al., 2024; Apipah et al., 2023).

The practicality criteria were obtained from students' responses to the administered instrument. Students were allowed to use the developed instrument and were subsequently interviewed about their experiences with it. For Item 1, students did not understand the question about the pattern of lines for the n-th term, as reflected in their answer sheets, leaving this part unanswered or resulting in incorrect responses. Some students determined the number of line patterns for the 5th and 10th terms instead. During the interviews, students demonstrated an understanding that the blue pattern of lines was obtained by multiplying 3 by the term number, the red pattern by multiplying 2 by the term number, and the yellow pattern by multiplying 1 by the term number. However, they admitted they were unable to express these relationships as a formula or generalization, such as blue pattern = $3n$, red pattern = $2n$, and yellow pattern = n.

For Item 2, students reported that they determined the number of *ume kbubu* that could be constructed by dividing the available amounts of reeds and bamboo rods by the required amounts, and then using the remaining materials to determine the number of *lopo*. In contrast, some students applied the reverse approach. For Item 3, students stated that the total weight of the portions of corn, pork, and moringa leaves was 3 kg. Based on these responses, students exhibited misconceptions regarding total weight and average weight. Some students attempted to determine the total weight of the three food components using the average formula. For Item 4, most students determined the number of gongs based on the available capital and interpreted the number of large gongs, allocating the remainder to small gongs. This problem generated a wide variety of student responses.

Based on students' responses and interview results, students understood the intent of the questions and what was being asked. In educational design research, practicality refers to the extent to which an instrument is easy to use, understandable, and feasible to be implemented in real classroom settings (Akker et al., 2013). It is also closely

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related to the clarity of instructions, language, time efficiency, and ease of use as perceived by users. Therefore, the instrument is considered highly practical for students (Nofrida et al., 2023).

The developed instrument demonstrates high reliability, indicating that it stimulates students to provide consistent responses. Based on students' work, most students gave consistent interpretations of the items, although some variations in answers were observed. The reliability in open-ended assessments is closely related to the coherence of students' reasoning across tasks (Darling-Hammond & Snyder, 2000). The observed variation in answers, rather than undermining reliability, reflects the instrument's intended design, which allows multiple valid approaches. Therefore, reliability should be understood in conjunction with validity, particularly in performance-based and open-ended assessments where diverse responses are expected.

The instrument is also classified as having a moderate level of difficulty. It is designed to challenge students to solve problems through multiple approaches, as reflected in the variety of responses they provide. Both in terms of difficulty and students' responses, the instrument can provide information about students' numeracy literacy abilities across different proficiency levels. This information needs to be supported by interviews to gain insight into students' thinking processes. This is further supported by the item discrimination power, which falls into the moderate category. The discrimination power is intended to distinguish between students with high, moderate, and low abilities. To further enhance the robustness of the findings, the quantitative data obtained from students' responses should be complemented with qualitative data from interviews. This triangulation approach allows for a deeper understanding of students' thinking processes and supports the interpretation of reliability not only in statistical terms but also in terms of response consistency and cognitive coherence (Contreras-Villalobos et al., 2024; Guest et al., 2012).

This may be attributed to students' limited prior experience with open-ended problems. In particular, for Items 1 and 2, students across high, medium, and low ability levels were unable to determine the number of blue, red, and yellow lines for the *n*-th term. Similarly, many students provided incorrect responses when determining the number of *kbubu* and *lopo*, often giving only a single, incomplete answer. Based on the analysis, this instrument is feasible for use in mathematics learning as a strategy to strengthen numeracy literacy through assessment. The instrument can stimulate students to solve problems using various approaches and to generate multiple alternative solutions.

The findings suggest that the developed instrument is not only valid, practical, and reliable but also pedagogically meaningful. It functions as both an assessment tool and a learning tool that can foster numeracy literacy by encouraging students to explore multiple strategies, justify their reasoning, and construct alternative solutions (Ibrahim et al., 2026; Akbar, 2025). This, in turn, can enhance students' creativity and help teachers explore students' abilities, thereby improving the quality of learning (Sa'idah et al., 2024). The limitation of the research is that the field test was conducted with students who had no prior experience with open-ended problems. Therefore, a recommendation from this study is to conduct field testing with students who already possess prior knowledge of open-ended problems and are studying relevant material, to obtain more optimal student responses and a better discrimination index for the instrument.

Conclusion

The open-ended numeracy literacy instrument, developed in the Timorese cultural context and based on Tessmer's preliminary study and formative evaluation stages, is feasible to use as a strategy for strengthening numeracy literacy in mathematics learning. The development results indicate that the instrument items are valid, practical, and reliable for measuring students' numeracy literacy skills, with moderate difficulty and moderate discrimination power. The instrument offers meaningful implications for both teaching and assessment practices. For teachers, the use of open-ended tasks embedded in local cultural contexts can support the implementation of more student-centered learning by encouraging multiple solution strategies, mathematical reasoning, and contextual understanding. Such tasks can be integrated into daily instruction not only as assessment tools but also as learning activities that promote discussion, reflection, and the exploration of diverse problem-solving approaches. The research is intended to be conducted with students with experience with open-ended problems to gain a deeper understanding of their responses and knowledge.

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Author's Declaration

Author Contribution	:	Author 1: Conceptualization, Writing - Original Draft, Writing – review & editing. Author 2: Formal analysis, Methodology, Writing – review & editing. Author 3: Writing – review & editing. Author 4: Writing – review & editing.
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