

Elementary School Students' Numeracy Profiles and the Need for Problem-Based Learning Grounded in Toba Batak Culture

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ABSTRACT:

This study was conducted to describe elementary school students' numeracy skills and identify the need for problem-based learning that incorporates Toba Batak culture as a learning context. It employed a descriptive exploratory design involving 60 fifth-grade students and eight teachers from four public elementary schools in Samosir Regency. Data were collected through three diagnostic numeracy tasks, student and teacher needs questionnaires, and an examination of students' written responses. The students obtained a mean score of 4.93 out of a maximum score of 12, equivalent to an attainment level of 41.1%. This result indicates that their numeracy skills require further development. The proportions of students who met the criterion also varied considerably across the three tasks, reaching 25.0% on the first task, 1.7% on the second, and 6.7% on the third. Their response patterns showed that the difficulties involved not only calculation but also analysing information, selecting appropriate solution strategies, and interpreting results in relation to the problem context. The overall student needs index was 84.4%. The highest need concerned the use of Toba Batak cultural contexts, at 86.9%, followed by PBL, at 85.4%. Among teachers, the overall needs index reached 92.0%, including 95.3% for cultural integration and 93.0% for PBL. The consistency between the diagnostic findings and the needs analysis provides an empirical basis for developing PBL grounded in Toba Batak culture to address students' numeracy learning needs.

Keywords: numeracy skills; Problem-Based Learning; Toba Batak culture; needs analysis; elementary school.

1. Introduction

Numeracy is demonstrated when individuals use mathematical knowledge and reasoning to understand information, formulate problems, choose appropriate methods, and interpret

results within a given context. It involves more than performing arithmetic operations. Students must also connect numbers, symbols, representations, and mathematical concepts with situations they encounter in everyday life.

Therefore, being able to perform calculations does not necessarily mean that students can apply those calculations when problems are presented as narratives, images, tables, or situations that require decision-making. Manfreda Kolar and Hodnik (2021) explained that solving contextual problems involves several connected processes, ranging from understanding the situation and identifying relevant information to constructing a mathematical model and evaluating the reasonableness of the result.

The need to strengthen numeracy in Indonesia is evident in the results of the 2022 Programme for International Student Assessment (PISA). Indonesian students obtained an average mathematics score of 366, compared with an OECD average of 472. Only approximately 18% of Indonesian students attained at least Level 2 proficiency, substantially below the OECD average of 69% (OECD, 2023b, 2023c). These figures cannot be used to describe elementary school students' abilities directly because PISA assesses students aged approximately 15 years. Nevertheless, the results reveal a broader challenge concerning students' ability to use mathematics in different situations. This national context reinforces the importance of establishing a strong numeracy foundation during elementary education.

At the elementary school level, numeracy plays an important role in the development of reasoning and problem-solving skills. This foundation also affects students' readiness for mathematics learning at subsequent educational levels. Numeracy assessment should therefore require more than recalling formulas or reproducing previously demonstrated procedures. It should also examine whether students can identify relevant concepts and use them flexibly. Purnamasari et al. (2023) suggested that numeracy tasks for fifth-grade students should use relevant contexts and address the cognitive demands of understanding, application, and reasoning. Kusuma and Nurmawanti (2023) similarly emphasised the need for tasks that encourage students to examine information carefully and solve problems for which a direct procedure is not immediately available.

Previous studies have shown that students' attainment can vary according to the form of the task and the reasoning it requires. Sulastri et al. (2024), for example, found that some students could identify information in a numeracy problem but were not always able to develop a strategy, connect the information with relevant mathematical concepts, or draw a conclusion. Such differences are difficult to identify when students' abilities are judged solely from their total scores. Examining the solution process is necessary to determine where difficulties emerge, whether in understanding the context, selecting a concept, performing a calculation, or explaining the meaning of an answer.

Diagnostic assessment can provide this more detailed information. An incorrect answer does not necessarily mean that a student has no understanding of the concept. One student may select the correct operation but make a computational error. Another may complete the calculation but fail to relate the result to the question. Some students may also recognise the relevant concepts but experience difficulty combining several pieces of information. Examining scores, criterion attainment for each task, and response patterns can therefore produce a more complete account of students' numeracy. From this perspective, assessment results are used to determine the instructional support students require, rather than to label students or compare the quality of schools.

One approach that is relevant to these needs is Problem-Based Learning (PBL). In PBL, a problem serves as the starting point for learning. Students are required to understand the situation, identify the information they need, develop strategies, discuss possible solutions, and explain their reasoning. Ayari et al. (2025), in their systematic review, found that PBL in K–12 mathematics education has frequently been used to develop problem-solving, student engagement, and mathematical thinking. At the elementary level, Purnomo et al. (2024) found that a problem-based module could support students' mathematical connections and habits of mind. Masliah et al. (2023) also reported that PBL could

support the development of elementary school students' literacy and numeracy.

The implementation of PBL, however, involves more than following a prescribed sequence of instructional steps. The quality of the problems influences how students participate in learning. Problems should be understandable, purposeful, and connected with experiences familiar to students. When a context is too unfamiliar, students must invest additional effort in understanding the situation before they can apply their mathematical knowledge. Local culture offers one possible source of familiar contexts. Ethnomathematics makes it possible to examine mathematical ideas embedded in the artefacts, activities, practices, and knowledge of a community. Batiibwe (2024) explained that this approach can connect school mathematics with students' cultural experiences without compromising the accuracy of the mathematical concepts being learned.

In Samosir Regency, Toba Batak culture offers various possibilities for developing numeracy problems. *Rumah Bolon*, *gora* ornaments, *ulos* patterns, musical instruments, traditional foods, and community social and economic activities can be examined through concepts such as numbers, measurement, geometry, patterns, proportions, and transformations. Br Ginting et al. (2024) identified several mathematical ideas in Batak culture, including lines, angles, geometric shapes, transformations, number patterns, and measurement. Ditasona (2023) found concepts of symmetry and transformation in Toba Batak carvings that could be developed into locally grounded mathematics materials. Saragih et al. (2022) also identified rectangles, rhombi, right triangles, isosceles triangles, and hexagons in *Ulos Hela* motifs. These studies demonstrate that Toba Batak cultural artefacts can provide meaningful resources for designing mathematical activities connected with students' surroundings.

The use of culture in mathematics instruction should not be limited to mentioning the names of cultural artefacts or placing their images in a task. Cultural elements must form part of the information students actually use to solve a

problem. Building dimensions, motif arrangements, geometric forms, material use, and community activities, for instance, can be presented as data that students need to calculate, compare, or interpret. In this way, culture becomes a source of mathematical activity rather than merely a narrative background. Its implementation must also consider the accuracy of cultural representation, alignment with learning objectives, students' prior knowledge, and teachers' readiness.

Previous research leaves several issues requiring further investigation. First, elementary numeracy studies have often been conducted in a single school, focused on instrument development, or designed to evaluate a particular instructional strategy. Evidence describing the numeracy profiles of students from several elementary schools in Samosir Regency remains limited. Second, most PBL studies have assessed learning outcomes after an intervention. Fewer studies have combined diagnostic assessment with analyses of student and teacher needs before instructional development begins. Third, research on Toba Batak ethnomathematics has identified mathematical concepts in various cultural artefacts, but these explorations have rarely been connected with students' numeracy difficulties and users' needs for culturally grounded problem-based learning.

The present study addresses these issues by bringing together two sources of evidence: a diagnostic numeracy assessment and instructional needs questionnaires. The participants were fifth-grade students and teachers from four public elementary schools located in four subdistricts of Samosir Regency. Including several schools allowed the study to capture some variation in school conditions and participant responses. However, the schools and participants were not selected through probability sampling. The findings are therefore not intended to represent all elementary school students in Samosir Regency. Instead, they describe the participating schools and provide an initial basis for designing instruction that responds to their needs. Specifically, this study aimed to describe fifth-grade students' numeracy profiles based on

a diagnostic assessment, identify their attainment and response patterns for each task, and analyse student and teacher needs for PBL grounded in Toba Batak culture. The results of these three analyses were then used to formulate an empirical basis for developing contextual numeracy instruction suited to students' characteristics. This study did not examine the effectiveness of PBL grounded in Toba Batak culture. Its purpose was to ensure that the subsequent development of the model would be informed by the difficulties observed in students' responses and the instructional support reported as necessary by both students and teachers.

2. Methodology

2.1. Research Design

This study employed a descriptive exploratory design that combined quantitative and qualitative analyses. The design was selected because the study was conducted at an initial stage before the instructional model was developed. Rather than examining the effect of an intervention, the study focused on describing students' numeracy skills and identifying the instructional support required by students and teachers. The design therefore provided initial evidence of the difficulties experienced by students and the perceived need

for Problem-Based Learning (PBL) grounded in Toba Batak culture.

Quantitative data were obtained from the diagnostic assessment scores and student and teacher responses to the needs questionnaires. Qualitative data were drawn from the solution steps written by the students and respondents' answers to the open-ended questions. The two forms of data were not analysed independently. Patterns found in the diagnostic scores and students' written responses were compared with the instructional needs reported by students and teachers. This comparison was used to examine the correspondence between the identified numeracy difficulties and the forms of instructional support considered necessary.

2.2. Participants and Research Setting

The study was conducted in four public elementary schools located in four subdistricts of Samosir Regency. The schools were purposively selected to include variation in geographical location and school context. The study involved 68 participants, comprising 60 fifth-grade students and eight teachers. Two teachers from each school participated and provided information about numeracy instruction and the support required to implement Problem-Based Learning (PBL) grounded in Toba Batak culture

Table 1. Distribution of research participants

School	Subdistrict	Students	Teachers
SD Negeri 29 Pardomuan I	Pangururan	20	2
SD Negeri 3 Pakpahan	Onan Runggu	9	2
SD Negeri 4 Sipinggan	Nainggolan	10	2
SD Negeri 7 Salaon Dolok	Ronggur Nihuta	21	2
Total	Four subdistricts	60	8

The student sample included fifth graders who were present during data collection and completed both instruments. Students who did not complete either the diagnostic tasks or the needs questionnaire were not included in the analysis. Because the schools and participants were not selected randomly, the results apply to the participating group. They should not be

interpreted as estimates of numeracy performance among all elementary school students in Samosir Regency.

2.3. Research Instruments

Data were collected from four sources: a diagnostic numeracy assessment, a student needs questionnaire, a teacher needs questionnaire, and

students' written responses. The diagnostic assessment was used to examine students' abilities and solution patterns, while the two questionnaires gathered information about instructional needs from the perspectives of students and teachers.

2.3.1. Diagnostic Numeracy Assessment

The diagnostic assessment consisted of three open-ended tasks on the area of plane figures. The tasks were arranged in order of increasing cognitive demand. The first task assessed students' use of basic concepts, the second required them to connect several pieces of information, and the third asked them to use their

calculations to make a contextually appropriate decision. In the first task, a rectangle and a triangle were presented as separate figures. Students calculated the area of each figure using the measurements provided in the diagram. In the second task, the two figures were combined to form a pentagonal shape. To determine its total area, students had to identify its constituent parts, calculate the area of each part, and then combine the results. The third task presented the context of painting the front section of a community security post. After calculating the area to be painted, students determined the number of paint cans required based on the coverage capacity of one can.

Table 2. Structure of the diagnostic numeracy assessment

Task	Task characteristics	Numeracy process assessed
1	Calculating the areas of a rectangle and a triangle using the measurements shown in the diagram	Using numbers, symbols, formulas, and units of measurement
2	Determining the area of a composite figure consisting of a rectangle and a triangle	Analysing and integrating information
3	Determining the number of paint cans required based on the area to be painted and the coverage capacity of the paint	Interpreting results and making a contextually appropriate decision

Each response was assessed using an analytic rubric ranging from 0 to 4. A score of 4 was assigned when a student applied the correct concepts and procedures, performed the calculations accurately, included the appropriate units, and provided a complete conclusion. A score of 3 was assigned to a response that was substantively correct but contained a minor omission that did not alter the main solution. A score of 2 indicated partial understanding, an incomplete procedure, or an inconsistency between the solution steps and the result. A score of 1 was assigned when a student made a relevant attempt but did not develop an adequate solution procedure. A blank or irrelevant response, or one that did not contain an assessable mathematical process, received a score of 0. The maximum score for each task was 4, giving a maximum total score of 12. At the task level, students were the resources and support required to implement PBL grounded in Toba Batak culture.

considered to have met the criterion if they obtained a score of 3 or 4. This threshold was selected because both scores indicated that the student had applied an essentially correct concept and procedure, although a response awarded a score of 3 could still contain a minor omission.

2.3.2. Student and Teacher Needs Questionnaires

The student and teacher questionnaires each contained 16 statements organised into four dimensions, with four statements in each dimension. The student questionnaire examined the difficulties students experienced and the forms of instruction they considered necessary. The teacher questionnaire gathered information about the difficulties observed during instruction and

Table 3. Student and Teacher Needs Questionnaires

Dimension	Measurement focus	Aspects assessed
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Numeracy challenges	Students' experiences and teachers' observations during problem-solving	Understanding information, selecting operations, connecting representations, and interpreting results
Need for PBL	Need for instruction that begins with a problem	Authentic problems, investigation, alternative strategies, discussion, and presentation
Toba Batak cultural context	Need to incorporate culture into numeracy instruction	<i>Rumah Bolon</i> , <i>ulos</i> , <i>gorga</i> , and the everyday life of Samosir communities
Implementation support	Resources and support required during instruction	Student worksheets, visual media, guiding questions, assessment rubrics, and teacher guidance

Responses were recorded using a four-point Likert scale: strongly disagree = 1, disagree = 2, agree = 3, and strongly agree = 4. An even-numbered scale was used to encourage respondents to indicate a clearer tendency rather than select a neutral midpoint. For the numeracy difficulties dimension, a higher score indicated greater difficulties experienced or observed. For the other three dimensions, a higher score indicated a greater need for PBL, Toba Batak cultural contexts, or implementation support. Both questionnaires also included open-ended questions. Students were asked to describe the

learning activities and media that they believed would help them understand mathematical problems. Teachers were asked to identify the learning materials, instructional resources, assessment rubrics, and forms of support required to implement PBL grounded in Toba Batak culture.

2.4. Data Collection Procedure

Data collection and processing were conducted in five stages. The sequence of activities, from participant selection to the formulation of the study findings, is presented in Figure 1.

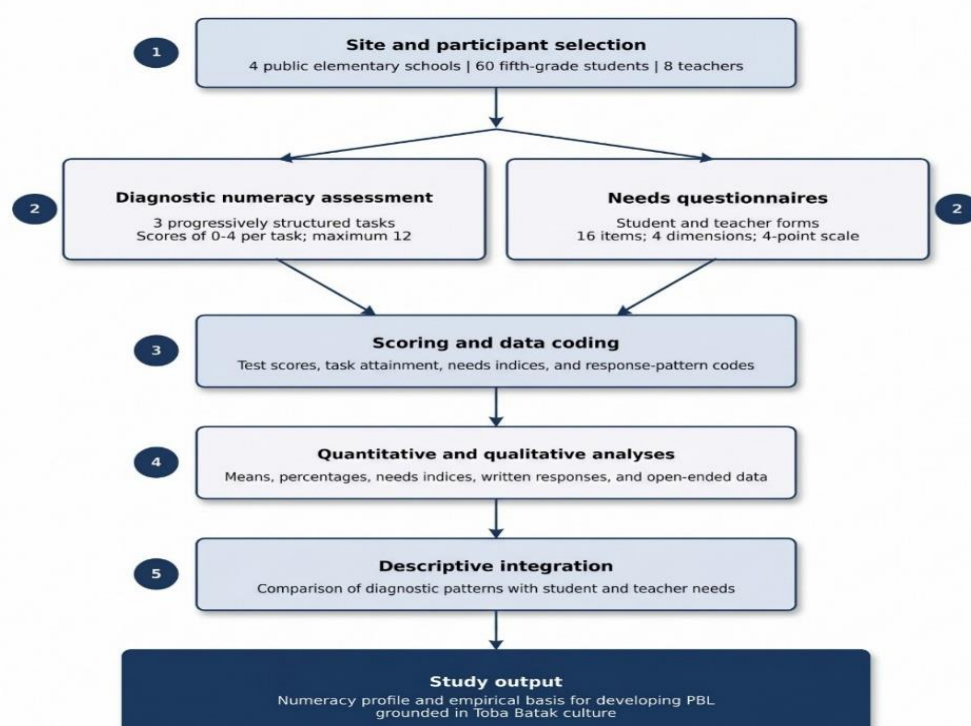


Figure 1. Research data collection, analysis, and integration procedure

The first stage involved selecting the schools and research participants. Four public elementary schools were included as the research sites, involving 60 fifth-grade students and eight teachers. Once the participants had been identified, two main sets of data were collected: students' diagnostic numeracy assessment results and responses to the needs questionnaires. All students completed the diagnostic assessment under the same instructions. Before beginning, they were asked to read each problem carefully. They were then required to write the formulas they used, show their calculation steps, include the appropriate units, and provide their final answers independently. This procedure allowed the researchers to examine not only the students' final answers but also the processes they followed when solving each task.

After completing the diagnostic assessment, the students responded to a questionnaire concerning the difficulties they experienced and their needs in numeracy learning. The teacher questionnaire was completed by two teachers from each school. The teachers responded based on their experience of teaching and observing mathematics lessons. To organise the data and protect participants' identities, each student response sheet was assigned a code based on the school and participant number. The third stage involved scoring the assessment and coding the data. Students' responses were evaluated using an analytic rubric ranging from 0 to 4. The evaluation considered the concepts applied, the accuracy of operations and calculations, the use of relevant information, the inclusion of measurement units, and the appropriateness of the final decision to the problem context. Questionnaire responses were tabulated according to the option selected for each statement. Students' written solutions and responses to the open-ended questions were then coded according to the patterns identified in the data.

In the fourth stage, quantitative and qualitative data were analysed according to their respective characteristics. The assessment scores were used to calculate the mean score, attainment percentage, and number of students who met the

criterion for each task. Questionnaire data were converted into needs indices at the item, dimension, and overall levels. Students' solution steps and open-ended responses were grouped according to shared characteristics so that recurring patterns could be identified. The final stage involved the descriptive integration of the findings. Difficulties identified in the diagnostic assessment were compared with the instructional barriers and needs reported by students and teachers. Bringing these two sources of evidence together produced a profile of students' numeracy skills and provided an empirical basis for developing PBL grounded in Toba Batak culture.

2.5. Data Analysis

2.5.1. Diagnostic Assessment Analysis

Each student's total diagnostic score was obtained by summing the scores across the three tasks. The percentage of numeracy attainment was calculated using the following formula:

$$P = \frac{\text{obtained score}}{\text{maximum possible score}} \times 100\%.$$

The mean score was calculated by dividing the sum of all students' scores by the number of participants. The percentage of students meeting the adequate performance criterion for each task was calculated as follows:

$$A_i = \frac{n_i}{N} \times 100\%,$$

where A_i represents the attainment percentage for task i , n_i represents the number of students obtaining a score of 3 or 4 on task i , and N represents the total number of students.

Students' written responses were analysed using four response-pattern categories. The first category was conceptual error, which referred to the use of an inappropriate concept or formula. The second was operational error, which referred to an inaccurate calculation despite the selection of an appropriate concept. The third was difficulty integrating information, which occurred when information from different parts of a figure or representation was not appropriately connected. The fourth was difficulty making a

contextual decision, which occurred when a numerical result was not interpreted according to the requirements of the problem. These categories were used to describe students' solution processes rather than to assign fixed ability labels.

2.5.2. Needs Questionnaire Analysis

The score for each questionnaire item was calculated from the frequency of responses in each category. The maximum possible score was

determined by multiplying the number of respondents, the number of questionnaire items, and the highest response score. The needs index was calculated as follows:

$$NI = \frac{\text{obtained score}}{\text{maximum possible score}} \times 100\%.$$

The index was calculated at the item, dimension, and overall questionnaire levels. The interpretation criteria are presented in Table 4.

Table 4. Interpretation of the needs index

Needs index	Category
81.25–100%	Very high
62.50–<81.25%	High
43.75–<62.50%	Low
25.00–<43.75%	Very low

Responses to the open ended items were analysed by grouping responses with similar meanings. The

frequency and percentage of each theme were then calculated. Student themes included the need for examples drawn from everyday life and local culture, group discussion, visual media, and step-by-step guidance. Teacher themes included the need for culturally grounded learning materials, student worksheets, reasoning-assessment rubrics, and implementation guidance.

2.5.2. Data Integration

The diagnostic assessment and needs questionnaire findings were integrated by comparing patterns across the two data sources. Students' use of mathematical concepts was compared with the numeracy challenges reported in the questionnaires. Their ability to integrate information was compared with the reported need for investigation, visual representations, and guiding questions. Their interpretation of results was compared with the need for authentic problems, discussion, presentation, and process-oriented assessment. Corresponding patterns

across the data sources were used to explain the relationship between students' demonstrated numeracy performance and their reported instructional needs. The analysis was limited to descriptive statistics and response-pattern interpretation because the study was not designed to test causal relationships or the effectiveness of an instructional model.

3. Results

3.1 Students' Numeracy Profiles

The analysis included the responses of 60 students to three diagnostic numeracy tasks. Each task had a maximum score of 4, resulting in a maximum total score of 12. The students obtained an overall mean score of 4.93, equivalent to 41.11% of the maximum score. Across the three tasks, the highest mean was obtained for Task 1 ($M = 2.00$). The mean scores for Task 3 and Task 2 were 1.52 and 1.42, respectively.

Table 5. Students' mean numeracy scores by school

School	n	Task 1	Task 2	Task 3	Mean total score (0–12)	Attainment (%)
SD Negeri 29 Pardomuan I	20	1.40	1.15	1.45	4.00	33.33
SD Negeri 3 Pakpahan	9	2.56	2.00	1.89	6.44	53.70
SD Negeri 4 Sipinggan	10	2.80	0.90	1.60	5.30	44.17
SD Negeri 7 Salaon Dolok	21	1.95	1.67	1.38	5.00	41.67
Overall	60	2.00	1.42	1.52	4.93	41.11

Descriptively, the overall attainment across the four schools ranged from 33.33% to 53.70%. SD Negeri 3 Pakpahan recorded the highest overall mean score of 6.44, equivalent to 53.70%. However, the task-level patterns varied across schools. SD Negeri 4 Sipinggan obtained the highest mean score for Task 1 at 2.80, whereas SD Negeri 3 Pakpahan recorded the highest mean scores for Task 2 and Task 3 at 2.00 and 1.89, respectively. Criterion attainment for each task was determined using a minimum score of 3. The results are presented in Table 6.

Table 6. Number of students meeting the criterion for each task

School	Task 1, n (%)	Task 2, n (%)	Task 3, n (%)
SD Negeri 29 Pardomuan I	1 (5.00)	0 (0.00)	1 (5.00)
SD Negeri 3 Pakpahan	4 (44.44)	0 (0.00)	3 (33.33)
SD Negeri 4 Sipinggan	8 (80.00)	0 (0.00)	0 (0.00)
SD Negeri 7 Salaon Dolok	2 (9.52)	1 (4.76)	0 (0.00)
Overall	15 (25.00)	1 (1.67)	4 (6.67)

Fifteen students, or 25.00%, met the criterion for Task 1. For Task 2, only one student, or 1.67%, met the criterion, while four students, or 6.67%, met the criterion for Task 3. No student met the criterion consistently across all three tasks. Attainment was more evident in the task presenting geometric shapes separately than in tasks requiring students to integrate multiple pieces of information and make context-based decisions.

3.2 Students' Response Patterns

The analysis of students' solution processes identified several response patterns across the three tasks. A single response could be assigned to more than one pattern because the coding process considered conceptual understanding, procedural accuracy, completeness, and the final result simultaneously.

Table 7. Distribution of students' response patterns

Response pattern	Task 1	Task 2	Task 3
Met the solution criterion	15	1	4
No response provided	0	1	6

Procedure for the rectangular component not yet accurate	8	8	0
Procedure for the triangular component not yet accurate	19	7	11
Components of the composite shape not integrated	0	11	0
Concept or procedure not yet accurate	9	23	6
Arithmetic inaccuracy	0	1	0
Incomplete solution	9	8	11
Contextual decision not yet accurate	0	0	16
Unit omitted or used inaccurately	0	0	6

Note. A response could be assigned to more than one category. Therefore, the total frequencies do not necessarily equal the number of students.

In Task 1, the most frequent difficulty involved calculating the area of the triangular component, a pattern identified in 19 responses. Several students recognised the triangle but did not apply the $\frac{1}{2}$ factor correctly or consistently, while nine responses showed an appropriate initial approach that was not completed. In Task 2, inaccurate application of concepts or procedures appeared in 23 responses. Eleven responses did not combine the areas of the constituent parts to determine the total area of the composite figure, and eight included only part of the required solution. These patterns show that students experienced greater difficulty when they had to identify the relationship between separate shapes and combine their calculations. In Task 3, the most common difficulty concerned using the

calculation result to make a contextually appropriate decision, which occurred in 16 responses. Eleven responses were incomplete, another 11 contained inaccurate calculations of the triangular component, and six omitted or incorrectly used the unit of measurement. Overall, some students could recognise the relevant geometric shapes and begin an appropriate calculation, but they did not consistently apply the required procedures, integrate the results, or use them to formulate a final decision that addressed the problem.

3.3 Learning Needs Based on Student and Teacher Perceptions

Learning Needs Based on Student and Teacher Perceptions presented in Table 8.

Table 8. Learning Needs Based on Student and Teacher Perceptions

Dimension	Students (%)	Category	Teachers (%)	Category
Need for numeracy support	80.5	High	89.1	Very high
Need for PBL	85.4	Very high	93.0	Very high
Integration of Toba Batak culture	86.9	Very high	95.3	Very high
Instructional implementation support	84.9	Very high	90.6	Very high
Overall needs index	84.4	Very high	92.0	Very high

Students' responses showed that the use of Toba Batak culture was their most prominent instructional need, with an index of 86.9%, followed by the need for PBL at 85.4%,

implementation support at 84.9%, and support for strengthening numeracy at 80.5%. At the item level, the strongest student response concerned numeracy problems drawn from everyday life and

local culture, which reached 89.2%. The use of *Rumah Bolon*, *ulos*, and *gora* as learning contexts obtained an index of 88.3%, while group discussions and the assignment of specific roles within groups reached 87.9% and 87.1%, respectively. Teachers reported a similar pattern but with higher indices. The integration of Toba Batak culture ranked first at 95.3%, followed by the need for PBL at 93.0%, implementation support at 90.6%, and support for strengthening numeracy at 89.1%. Four teacher questionnaire

items obtained the same index of 96.9%: the use of authentic problems, alignment between cultural contexts and learning objectives, the use of culture to encourage student engagement, and the availability of ready-to-use instructional resources. Overall, the responses of both groups reflected a preference for culturally relevant and problem-based numeracy learning, while the teachers also emphasised the need for practical resources to support classroom implementation.

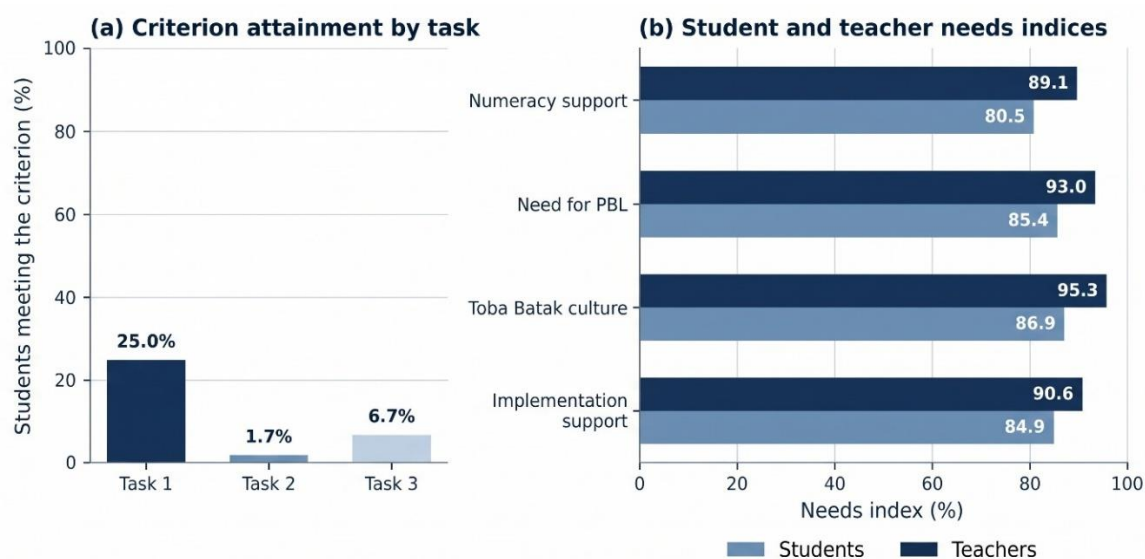


Figure 2. Criterion attainment for each diagnostic task and learning needs indices reported by students and teachers.

3.4 Students' and Teachers' Open-Ended Responses

Open ended responses were analysed to clarify the patterns obtained from the closed-ended questionnaire. Because respondents could report more than one need, each response theme was analysed separately.

Table 9. Learning needs identified from open-ended responses

Respondents	Response theme	n	Percentage (%)
Students	Preferred examples from everyday life and local culture	38	63.3
Students	Preferred group discussion activities	33	55.0
Students	Needed visual media or representations	27	45.0
Students	Needed systematic solution steps	24	40.0
Teachers	Culturally contextualised numeracy materials were not adequately available	7	87.5
Teachers	Needed ready-to-use student worksheets	8	100.0
Teachers	Needed a rubric for assessing reasoning processes	7	87.5
Teachers	Needed instructional implementation guidelines	6	75.0

Thirty-eight students, or 63.3%, preferred problems derived from everyday life and local culture. Thirty-three students, or 55.0%, expressed a preference for group discussion activities. Twenty-seven students, or 45.0%, reported a need for visual media, while 24 students, or 40.0%, indicated a need for more systematic solution steps. All participating teachers reported a need for ready-to-use student worksheets. Seven of the eight teachers indicated a need for culturally contextualised numeracy materials and rubrics for assessing students' reasoning processes. Six teachers reported a need for instructional implementation guidelines.

3.5 Descriptive Convergence of the Findings

The diagnostic assessment and questionnaire findings showed descriptively convergent patterns. Task 2, which required students to decompose and integrate several geometric components, had a criterion-attainment rate of 1.67%. Task 3, which required students to use their calculations to make a contextual decision, had a criterion-attainment rate of 6.67%. At the same time, the need for PBL reached 85.4% among students and 93.0% among teachers.

The integration of Toba Batak culture obtained an index of 86.9% among students and 95.3% among teachers. The open-ended responses supported this pattern. A total of 63.3% of students preferred problems derived from everyday life and local culture, while 87.5% of teachers reported a need for culturally contextualised numeracy materials. Overall, the empirical profile revealed three main characteristics: students employed varied strategies when solving numeracy tasks; response patterns became more diverse when tasks required the integration of information and contextual decision-making; and both students and teachers reported a strong need for problem-based learning grounded in Toba Batak culture.

4. Discussion

4.1 Students' Numeracy Profiles

The diagnostic assessment showed that students obtained a mean score of 4.93 out of a maximum score of 12, equivalent to 41.11%. This score

does not merely reflect their ability to calculate the area of plane figures. Students also had to understand the information provided, select appropriate concepts, connect different components of the figures, and interpret their results within the problem context. The assessment therefore provides insight into students' ability to apply mathematical knowledge, rather than simply use formulas and perform calculations.

Students' attainment differed considerably across the three tasks. A total of 25.00% of the students met the criterion for Task 1, compared with only 1.67% for Task 2 and 6.67% for Task 3. Students performed better when the rectangle and triangle were presented separately. They experienced greater difficulty when required to decompose a composite figure, combine the results of their calculations, and use those results to determine the number of paint cans needed. No student met the criterion across all three tasks. This finding suggests that knowledge of basic procedures was not always applied flexibly to problems with different structures and contexts.

Overall attainment across the four schools ranged from 33.33% to 53.70%. However, the school with the highest overall score did not consistently achieve the best result on every task. This variation may be related to differences in students' strategies and learning experiences, but it should not be used to compare school quality. The number of participants differed across schools, and the schools were not selected through probability sampling. The findings therefore describe only the participating groups and do not represent all elementary school students in Samosir Regency.

4.2 Response Patterns and Numeracy Reasoning Processes

Examining students' solution steps revealed information that was not evident from their total scores. In Task 1, the most frequent difficulty involved calculating the area of the triangle. Nineteen responses showed that the $\frac{1}{2}$ factor had not been applied correctly or consistently. Some students recognised the triangular shape in the task but did not fully connect its properties with

the appropriate area formula. In Task 2, inaccurate use of concepts or procedures was identified in 23 responses. In addition, 11 responses did not combine all components of the figure to determine its total area. This task required more than accurate calculation. Students had to decompose the composite figure, identify the required measurements, calculate the area of each component, and then combine the results. An error or omitted step at any stage led to an inaccurate or incomplete final solution.

The main difficulty in Task 3 emerged when students had to use their calculations to address the problem. Sixteen responses did not produce an appropriate contextual decision, 11 were incomplete, and six omitted the unit of measurement or used it incorrectly. These patterns show that solving a numeracy task does not end with obtaining a numerical result. Students must also evaluate whether the result is reasonable, relate it to the given situation, and communicate a clear final decision. This process is consistent with the PISA framework, which regards the interpretation of mathematical results in real-world contexts as an important component of mathematical literacy (OECD, 2023a). The variety of responses shows that students' abilities cannot be represented by a single uniform pattern. Some students selected a relevant strategy but did not complete all stages of the solution. Others completed the calculations but did not explain t

4.3 Relevance of Problem-Based Learning to the Diagnostic Findings

The needs index for PBL reached 85.4% among students and 93.0% among teachers, indicating that both groups regarded learning that begins with a problem, involves investigation, and allows students to compare different strategies as necessary. Students' open-ended responses supported this pattern, with 55.0% preferring group discussion activities and 40.0% reporting a need for more structured and systematic problem-solving steps. These needs were consistent with the difficulties identified in the diagnostic assessment. In Task 2, students experienced difficulty decomposing the

composite figure and connecting its constituent parts, pointing to the need for activities that help them break down problems, organise information, and explain relationships among components. In Task 3, some students completed the calculations but did not use their results to make an appropriate decision. Instruction should therefore provide opportunities for students to examine their results, discuss their reasoning, and explain the basis for their decisions.

These characteristics align with PBL, in which a problem initiates the learning process and is followed by information identification, strategy development, discussion, solution presentation, and reflection. A systematic review of 40 PBL studies in K–12 mathematics identified geometry as the most frequently investigated domain. The review also identified problem-solving, reasoning, motivation, and collaboration as commonly assessed learning outcomes. In addition, PBL was frequently integrated with ethnomathematics, technology, games, and STEM approaches (Ayari et al., 2025). These findings support the conceptual alignment among PBL, geometry, and the numeracy needs identified in the present study. Gufron et al. (2025) reported a large overall effect of PBL on mathematical literacy. However, its effectiveness varied according to educational level, students' learning styles, intervention duration, and the relevance of the problems presented. Research on geometry learning has also reported different effects across cognitive dimensions. Tursynkulova et al. (2023) found that PBL significantly improved problem-solving and creativity in geometric construction tasks, whereas its effects on critical thinking, logical reasoning, and decision-making were not statistically significant. These findings indicate that the effectiveness of PBL depends on the quality of the problems, the scaffolding provided, group interactions, and the assessment methods employed.

Accordingly, the high needs indices found in this study do not demonstrate that PBL has already improved students' numeracy. The questionnaire measured perceptions, acceptance, and

instructional needs rather than intervention effects. Evidence of effectiveness would require implementation of the proposed model and measurement of subsequent changes in students' numeracy. Nevertheless, the convergence of the diagnostic results, questionnaire data, and open-ended responses provides a strong empirical basis for adopting PBL as the focus of subsequent instructional development.

4.4 Integrating Toba Batak Culture into Numeracy Learning

The integration of Toba Batak culture obtained the highest needs indices among both students and teachers, at 86.9% and 95.3%, respectively. A total of 63.3% of the students preferred examples derived from everyday life and local culture. At the item level, the use of contexts related to *Rumah Bolon*, *ulos*, and *gorga* also received very high ratings. These findings indicate that local culture is perceived as a relevant source of context for numeracy learning. Cultural integration should extend beyond the use of names, pictures, or ornaments as superficial features of a task. Cultural elements should embody authentic mathematical relationships. The structure of *Rumah Bolon* can be used to identify, decompose, and recombine geometric shapes. Patterns in *ulos* and *gorga* can support the study of regularity, symmetry, proportion, measurement, and visual representation. Community activities can also be developed into problems involving estimation, measurement units, resource planning, and decision-making. Hendriyanto et al. classified ethnomathematical resources into cultural ideas, activities, and artefacts. Their systematic review identified geometry as the most frequently investigated mathematical domain in ethnomathematics research (Hendriyanto et al., 2023).

Batiibwe (2024) identified buildings, games, weaving, food, number systems, and community practices as cultural resources that can inform teaching materials, learning activities, and assessment. Simply including these elements, however, does not make a task culturally meaningful. Their educational value depends on how they are connected to the mathematical ideas

and reasoning expected from students. Culture should shape the mathematical activity within a task rather than appear only as a name, picture, or decorative background. A review by Iffah et al. (2025) showed that only 15% of Indonesian ethnomathematics studies focused on elementary education, compared with 27% at the junior secondary level. Buildings comprised 36% of the cultural products investigated, while traditional crafts accounted for 33%. These figures point to the need for more ethnomathematics research in elementary education and across a broader range of regions and cultural settings. In the present study, Toba Batak culture is therefore used as a source for developing situations in which students can engage in meaningful mathematical activity.

Familiarity with a cultural object does not, by itself, improve numeracy. A suitable context must correspond with the intended learning outcome, contain information that students can analyse mathematically, and prompt genuine mathematical activity. Its pedagogical contribution lies in making a problem accessible while still requiring students to move from familiar experience towards mathematical representation and abstraction.

4.5 Teachers' Views on Implementation Support

The implementation-support index reported by teachers reached 90.6%. All eight teachers requested ready-to-use student worksheets, seven teachers (87.5%) identified a need for reasoning-assessment rubrics, and six teachers (75.0%) requested implementation guidelines. These responses suggest that positive views of culturally grounded PBL are not sufficient for classroom use. Teachers also require practical resources that translate the approach into a manageable sequence of activities. The requested worksheets should help students identify the problem, distinguish relevant from irrelevant information, construct representations, compare possible strategies, and formulate a conclusion. The demand for assessment rubrics is equally important. Diagnostic responses showed that students sometimes demonstrated a relevant

concept or strategy even when the final answer was incomplete or inaccurate. An analytic rubric could distinguish among conceptual understanding, strategy selection, representation, calculation, interpretation, and mathematical communication.

Astuti et al. (2024) found that teachers' beliefs about ethnomathematics-based numeracy learning involved their understanding of numeracy, the role assigned to culture, preferred instructional practices, and expectations of student activity. Positive views alone are unlikely to change classroom practice unless teachers are given clear procedures and materials suited to everyday teaching conditions. Mania and Alam (2021) found that teachers generally viewed ethnomathematics favourably, but their ability to apply it was influenced by their knowledge, access to learning resources, and instructional readiness. In the present study, teachers' responses similarly point to the need for practical support. The proposed model should therefore be accompanied by student worksheets, assessment instruments, and clear implementation guidelines.

5. Conclusion

This study provides a profile of elementary school students' numeracy skills and identifies the need for problem-based learning that uses Toba Batak culture as a learning context. The diagnostic assessment completed by 60 students produced a mean score of 4.93 out of 12, equivalent to 41.11%. The proportion of students who met the criterion varied across the tasks, reaching 25.00% in Task 1, 1.67% in Task 2, and 6.67% in Task 3. Students performed better when the rectangle and triangle were presented separately. They experienced greater difficulty when required to combine different components

of a figure, use measurement units correctly, and translate their calculations into a contextually appropriate decision. Although some students recognised the relevant concepts and began suitable solution procedures, they did not always complete the entire process accurately.

The questionnaire results indicate that students and teachers need numeracy instruction that begins with a problem and is connected with local culture. The overall needs index reached 84.4% among students and 92.0% among teachers. The use of Toba Batak culture was the most prominent need, with an index of 86.9% among students and 95.3% among teachers. Open-ended responses also showed that students preferred problems related to their everyday lives and cultural surroundings. Teachers, meanwhile, reported a need for student worksheets, contextual learning materials, rubrics for assessing reasoning processes, and guidelines to support classroom implementation.

Taken together, the diagnostic assessment, questionnaire data, and open-ended responses provide an empirical basis for further developing PBL grounded in Toba Batak culture. Cultural elements should serve as sources of meaningful mathematical problems that engage students in understanding information, constructing representations, comparing strategies, performing calculations, and making decisions. However, this study describes only the skills and needs of participants from the four schools involved. It does not establish the effectiveness of the proposed model, and its findings are not intended to represent all elementary school students in Samosir Regency.

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