Journal of Current Studies in SDGs
Homepage : https://journal.i-ros.org/index.php/JOCSIS
Email : jocsis@i-ros.org

e-ISSN 3089-7564
Vol.2, No.2, June 2026

Development of a Sigi Cultural Ethnomathematics-Based Student Learning Needs Questionnaire to Support SDG 4: Quality Education

Mailili Wahyuni H[1,2*], Jamhari Mohammad[1], Ratman[1], Astija[1]

[1]Tadulako University, Palu, Indonesia
[2]Alkhairaat University, Palu, Indonesia

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DOI : https://doi.org/10.63230/jocsis.2.2.179

Sections Info

Article history:
Submitted: May 20, 2026
Final Revised: June 4, 2026
Accepted: June 10, 2026
First Available Online: June 26, 2026
Publication Date: June 27, 2026

Keywords:
Cultural-Based Teaching Materials;
Ethnomathematics;
Instrument Development;
Sigi Culture;
Student Characteristics;
Students' Learning Needs.

ABSTRACT

Objective: *To develop a valid and reliable questionnaire and teacher interview instrument for assessing students' learning needs and characteristics in junior high schools in Sigi Regency, and to analyze these needs as a basis for developing Sigi culture-based ethnomathematics teaching materials.* ***Method:*** *The study employed a Research and Development (R&D) approach using the 4D model (Define, Design, Development, and Dissemination). Instrument development involved needs analysis, instrument design, expert validation, empirical testing, and reliability analysis.* ***Results:*** *Expert validation indicated that the instruments were feasible for use with minor revisions. Empirical testing showed that 17 of 26 questionnaire items and 11 of 15 interview questions were valid. Reliability analysis produced coefficients of 0.786 for the questionnaire and 0.798 for the interview guideline, indicating good reliability.* ***Novelty:*** *Developing and validating a student learning needs questionnaire specifically designed to support the development of Sigi cultural ethnomathematics-based mathematics teaching materials. By integrating students' learning needs with local cultural contexts, the instrument provides a systematic framework for designing culturally responsive mathematics instruction that contributes to SDG 4 (Quality Education) through inclusive, contextual, and meaningful learning while supporting the preservation of local cultural heritage in line with SDG 11 (Sustainable Cities and Communities).*

INTRODUCTION

In Indonesia, most students consider mathematics as one of the difficult subjects (Wijaya et al., 2019; Jupri et al., 2014). This is supported by data and facts, including Based on the results of the 2018 PISA (Programme for International Student Assessment) test, Indonesia was ranked 72 out of 79 participating countries for students' mathematics abilities (OECD, 2019). Meanwhile, in the 2019 TIMSS (Trends in International Mathematics and Science Study) test, Indonesia was ranked 45 out of 58 participating countries for mathematics (Mullis et al., 2020). The results of the 2021 National Assessment of Minimum Competency Assessment (AKM) data show that the average mathematics score of junior high school students in Indonesia is still below the Graduate Competency Standards. The results of the 2019 National Examination (UN) show that the average mathematics score of junior high school students is still below the average score for other subjects. This is also complained about by many mathematics teachers who report difficulties in teaching mathematical concepts to students.

Students often complain that mathematics is a difficult, boring, and less relevant subject to everyday life. This is caused by several factors, including: mathematics is seen as an abstract subject and less related to students' everyday lives. This condition also occurs in junior high school students in the Sigi area, Central Sulawesi.

Some factors that cause mathematics to be considered difficult include the abstract nature of mathematics, students' lack of basic abilities (Mullis et al., 2017), lack of motivation to learn (Agustyaningrun et al., 2021) and less contextual mathematics

learning. Therefore, innovative efforts are needed in mathematics learning, one of which is by using an ethnomathematics approach that can help students understand mathematical concepts more meaningfully. One approach to mathematics learning that can be applied to overcome this problem is by using an ethnomathematics approach. Ethnomathematics is an approach that links mathematics learning with local culture. Ethnomathematics is a mathematical concept that grows and develops in a particular culture. This approach can help students understand mathematical concepts more concretely and meaningfully because they are related to their environment and culture.

Sigi culture has rich potential to be developed in ethnomathematics-based mathematics learning (Suciati et al., 2023). Sigi is one of the regions in Central Sulawesi that has a variety of local wisdom, both in terms of customs, arts, and daily activities of the community. Mathematical elements can be found in various forms of Sigi culture, such as woven motifs, traditional house shapes, traditional measurement systems, and others.

However, the utilization of the ethnomathematics potential of Sigi culture in mathematics learning has not been utilized optimally in mathematics learning in schools in the area (Batiibwe et al., 2025; Simbolon, 2024). especially at the junior high school level. In developing this potential, teachers still have difficulty in developing teaching materials and assessment instruments based on ethnomathematics. Therefore, it is necessary to develop a mathematics learning questionnaire instrument with a Sigi cultural ethnomathematics approach. This instrument is expected to help teachers in measuring students' understanding of concepts, creativity, and mathematical disposition by linking them to the local cultural context.

This study differs from previous research by developing a questionnaire and interview guide specifically for the ethnomathematics approach of Sigi culture at the junior high school level. The novelty of this study lies in its instrument designed to help teachers understand students' learning needs, measure mathematical understanding, and integrate local cultural contexts to make learning more meaningful and aligned with the characteristics of Sigi students.

Therefore, this study aims to develop and validate a student learning needs questionnaire for Sigi cultural ethnomathematics-based mathematics learning among junior high school students. The proposed instrument is expected to provide empirical data for designing culturally responsive mathematics teaching materials that address students' learning needs while contributing to the implementation of SDG 4 (Quality Education) through inclusive and contextual learning and supporting SDG 11 (Sustainable Cities and Communities) through the preservation of local cultural heritage.

RESEARCH METHOD

The research method that will be used in the research on the development of the student needs and characteristics questionnaire instrument and the teacher interview sheet is the research and development method (R&D) which aims to develop the instrument. In general, the research and development method (R&D) which aims to develop the instrument involves a systematic process, starting from needs analysis, instrument design, validation, trials, to refinement) to produce an instrument that is valid, reliable, and in accordance with the measurement objectives (Huang et al., 2022; Floyd & Widaman, 1995; Lee, 2024). Research and development has cyclical steps, namely product development steps, trial steps, product validity and reliability testing steps. These steps are carried out in several cycles which ultimately produce the best final research product.

This method is used because it is considered in accordance with the objectives of the research, namely to test the validity and reliability of the student needs and characteristics questionnaire and the teacher interview sheet. Research and development is a research method used to develop and validate a new product and test a product so that it can be accounted for.

The research and development method used in this study is the Thiagarajan 4D model, namely: (1) the definition stage (Define), (2) the design stage (Design), (3) the development stage (Develop), (4) the dissemination stage (Dissemination). The 4D activity procedure includes four stages which are described as follows: The first stage of definition (Define), namely in this first stage a qualitative approach with the literature reviews method with the narrative review type (Ferrari, 2015; Johnson & Green, 2022) articles, journals, and textbooks related to the existing learning needs and student characteristics questionnaire instrument, to compile a conceptual definition and competency of the instrument to be developed. The second stage of planning (Design), namely in this second stage compiling a draft of the instrument construction and compiling indicators for the learning needs and student characteristics questionnaire instrument. The third stage of development (Develop), namely in this stage there are several steps, namely the first step is to conduct a content validity test, by discussing with lecturers and mathematics teachers to align perceptions of the draft construction of the student learning needs questionnaire instrument. The results of the discussion were input for improving the draft construction of the instrument. After being revised, the expert test of the student learning needs questionnaire instrument construction was continued (Artino et al., 2014; Aiken, 1985). The results of the assessments of several validators were collected and analyzed using the Aiken V formula. After the instrument was declared valid, it was continued with a field trial test at Public Junior High School 13 Sigi, then an analysis of the reliability test and level of difficulty was carried out. The last stage is the dissemination stage, namely distributing instruments that are valid and suitable for use to several schools.

Data analysis

Validity test

The validity of the instrument can be reviewed from two aspects, namely the overall validity of the instrument and the validity of the instrument items. The validity of the questionnaire instrument on learning needs and student characteristics was analyzed using the "Aiken's validity coefficient". Aiken (1985) formulated the Aiken's V formula to calculate the content-validity coefficient based on the assessment results of a panel of experts consisting of n people on an item in terms of the extent to which the item represents the construct being measured. The formula proposed by Aiken shows Table 1.

Table 1. The validity categories based on the V value

Value Range V	Validity Level	Description
0.80<V≤1.00	Very High Validity	Very Good
0.60<V≤0.80	High Validity	Good
0.40<V≤0.60	Moderate Validity	Sufficient
0.20<V≤0.40	Low Validity	Less
0.00<V≤0.20	Very Low Validity	Very Less
V<0.00	Invalid	-

Reliability test

An instrument can be said to be reliable and trustworthy if the instrument is reliable. Reliability according to Suharsimi Arikunto (2015) is an instrument that is reliable enough to be used as a data collection tool because the instrument is good. Reliability is an important characteristic that shows consistency, stability or consistency of measurement results over time and the equality of measurement results of an instrument (Taber, 2018). To calculate the reliability test, the Cronbach alpha formula.

The test criteria is if the calculated r is greater than the table r with a significance level of $\alpha = 0.05$, then the instrument is reliable, conversely if the calculated r is smaller than the table r then the instrument is not reliable.

RESULTS AND DISCUSSION

Results

This research is a development research, so the product of this research is an instrument in the form of a questionnaire on learning needs and characteristics of students and interview guidelines (Holmes, 2023). For data analysis and research results obtained in each stage of the development of the 4-D model are presented as follows (Hl et al., 2023).

Define stage

The first stage of the study employs a qualitative approach through a literature review, examining articles, journals, and textbooks related to the student learning needs questionnaire instrument and analyzing aspects and indicators of student characteristics. This stage involves assessing student needs for mathematics learning and identifying opportunities to integrate Sigi cultural ethnomathematics into the curriculum (Batiibwe, 2025). The existing student learning needs questionnaires include various question types aimed at establishing conceptual definitions and competencies for future instruments. Key elements of this process involve analyzing guidelines for creating interview sheets, focusing on construction, language, and materials. The questionnaire addresses aspects such as learning activities measuring student preferences for mathematics subjects, learning styles, and subject repetition alongside an examination of learning resources, including current usage and desired materials (Siregar, 2024). Additionally, it evaluates students' knowledge of ethnomathematics based on their experiences with mathematics in everyday life and culture, cultural awareness, and opinions on culturally relevant learning. Lastly, the desired learning materials are analyzed for content relevance and assessment methods.

Design stage

This design stage is carried out to design a questionnaire instrument for students' learning needs including: Instrument aspects, indicators, item numbers and item questions, while in designing the interview sheet includes: item numbers, statements and responses. The grid of the student learning needs questionnaire instrument and the grid of the interview sheet are presented in Table 2 and Table 3 below.questionnaire

Up to here, it is illustrated that the output of this study is an input for the preparation of marketing strategies so that business entities can determine the stages of strategy and targets to be achieved. The results of this study are important as part of the initial data and information in building a marketing strategy. As it is believed that good data accuracy and validity will make a good strategy (Liu et al., 2023; Hendrawan et al., 2023). Where a good strategy is to have accurate data, the measurement approach used, and the

analysis and measurement of the progress of implementing a strategy (Yuliani et al., 2023; Guo & Gu, 2022). The following presentation below discusses research results using the Boston Consulting Group (BCG) Analysis tool in other case studies.

Table 2. Grid of the student learning needs questionnaire instrument

Aspect	Indicator	Question Number
Learning Activities	➢ Mathematics subjects according to students ➢ Student learning styles ➢ Repeating subjects	1, 2, 3, 4, 5 6, 7
Learning Resources	➢ Learning resources used ➢ Supporting learning resources ➢ Learning resources desired by students	8, 9 10 11, 12, 13
Students' Knowledge of Ethnomathematics	➢ Students'learning experiences about mathematics related to everyday life and culture ➢ Students' knowledge of culture ➢ Students' opinions about learning with cultural elements	14, 15, 16, 17,18, 19, 20, 21, 22,23
DesiredStudent Teaching Materials	➢ Content in teaching materials ➢ Size	24, 25, 26
Number of Questions		26

Table 3. Interview sheet grid

No	Material aspects	Questions/ items
1	Exploring aspects of students' learning activities/learning tendencies	1,2,6
2	Exploring information on students' learning difficulties in mathematics	3,4,5
3	Digging up information on learning resources used by students	7,8,9
4	Digging up information on the forms of teaching materials that are frequently used	10,11,12
5	Exploring information on mathematics teaching materials based on culture or ethnomathematics in relation to Sigi culture	13,14,15

Development phase (Develop)

This stage involves expert validation activities and instrument development testing.

Expert validation

At this validation stage, it is done by providing a questionnaire instrument for learning needs and student characteristics and interview sheet guidelines to 2 validators, namely by 2 lecturers of learning assessment and evaluation.

Based on the analysis results, the developed interview guideline included 7 items with very high validity, 5 items with high validity, and 3 items with sufficient validity. The items deemed to have sufficient validity were revised based on suggestions from two validators, focusing on clarifying the questions, reducing the use of "whether," and employing standard language (Cheung et al., 2024; Lambert & Newman, 2023). After

these revisions, the validators confirmed that the questionnaire could be used with only minor adjustments.

Validity analysis is carried out to determine the validity of an instrument, namelythe extent to which the developed measuring instrument can measure what it should measure. Yin and Lee (2023) defines validity as the extent to which an instrument measures what it is intended to measure. Validity is related to the accuracy and suitability of the instrument in measuring the intended construct. The results of the validity test will show how valid an instrument is in carrying out its measuring function (Taherdoost, 2022; Yin & Lee, 2023; Cruchinho et al., 2024). The validity of the test items was calculated using SPSS.20 and obtained the results as in the Table 4 and Table 5.

Table 4. Validity results of questionnaire items for learning needs and student characteristics

Validity index	Item	Amount	%
> 0.349 (Valid)	3, 7, 11, 12, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24,25,26	17	65.38%
<0.349 (Invalid)	1,2, 4, 5, 6, 8, 9, 10, 13	9	34.6%

Based on the results of the validity analysis of the learning needs questionnaire and student characteristics above, several items still need to be considered.

Table 5. Item validity results

Validity index	Item	Amount	%
> 0.349 (Valid)	1, 2,4, 5, 6, 9, 10,11,12,13,14,15	11	73.3%
<0.349 (Invalid)	2, 3, 7, 8	4	26.6%

Based on the results of the validity analysis of the interview guidelines above, several questions still need to be considered. Results of the reliability coefficient for the learning needs questionnaire instrument and student characteristics of 0.786 and interview guideline instruments of 0.798. According to Fraenkel et al. (2012), an instrument is said to be reliable if its reliability factor is greater than 0.70, so it can be concluded that the instrument is reliable because its reliability coefficient is greater than 0.70. A good instrument will provide the same measurement results and have consistent answers (Doran et al., 2026). This is in line with Widyoko's (2018) opinion that a test is said to be trustworthy or reliable if it provides consistent results when tested repeatedly.

Dissemination stage

This stage is carried out to disseminate the products developed in 5 schools in Sigi Regency in class VII of Public Junior High School 8 Sigi, class VII students of Public Junior High School 12 Sigi, class VII students of Public Junior High School 5 Sigi, class VII of Public Junior High School 2 Sigi and class VII of Public Junior High School 4 Sigi. The reason for choosing these schools is because of the suitability of the learning program to be developed with the needs and characteristics of the local community (Sakti et al., 2024).

Discussion

The findings demonstrate that the developed student learning needs questionnaire and interview guidelines provide a valid and reliable foundation for identifying students' learning characteristics and supporting the development of Sigi cultural ethnomathematics-based teaching materials. The systematic implementation of the 4-D development model enabled the instrument to be constructed through a comprehensive process consisting of needs analysis, instrument design, expert validation, testing, and dissemination. This structured development process ensured that the resulting instrument accurately represented students' learning needs while reflecting local cultural contexts.

The define stage revealed that students' learning needs encompass multiple dimensions, including learning activities, learning resources, prior knowledge of ethnomathematics, and preferences for culturally relevant teaching materials. These findings indicate that mathematics learning should not be designed solely from curriculum requirements but should also consider students' learning preferences, cultural experiences, and contextual understanding. Such an approach is consistent with culturally responsive education, which emphasizes that learning becomes more meaningful when instructional materials are connected with students' real-life experiences and cultural identities. Consequently, identifying students' learning needs before developing instructional materials increases the likelihood that the resulting teaching resources will be relevant, engaging, and responsive to learners' characteristics.

The design stage further demonstrates the importance of developing comprehensive indicators that capture both pedagogical and cultural dimensions of learning. The inclusion of questions related to learning activities, learning resources, ethnomathematical knowledge, and preferred teaching materials reflects a holistic understanding of students' learning processes. Rather than focusing exclusively on cognitive aspects, the instrument recognizes that students' cultural knowledge and everyday experiences influence how mathematical concepts are understood and applied. This finding reinforces previous studies suggesting that integrating local cultural contexts into mathematics education can improve conceptual understanding while strengthening students' cultural identity.

The expert validation process confirmed that the developed instrument possesses satisfactory content validity after several revisions. The recommendations provided by validators primarily addressed language clarity, question construction, and the use of standard terminology, indicating that careful refinement contributes to improving instrument quality. Similarly, the statistical validation results showed that most questionnaire and interview items met the required validity criteria, while invalid items were identified for revision or elimination. This iterative validation process enhances the instrument's ability to measure students' learning needs accurately and supports its application in educational research and instructional planning.

The reliability analysis further strengthens the quality of the developed instrument. The reliability coefficients of 0.786 for the questionnaire and 0.798 for the interview guidelines exceed the commonly accepted threshold of 0.70, indicating satisfactory internal consistency. These results suggest that the instrument produces stable and consistent measurements across respondents, making it suitable for identifying students' learning needs in mathematics education. Reliable instruments are essential because educational decisions regarding curriculum development and instructional design depend on accurate and dependable information about learners' characteristics.

The dissemination of the instrument across five junior high schools in Sigi Regency also demonstrates its practical applicability in different educational settings. The successful implementation across multiple schools indicates that the instrument is sufficiently adaptable to accommodate variations in student characteristics while maintaining its relevance to the local cultural context. This finding suggests that the instrument may serve as an effective needs assessment tool for developing ethnomathematics-based teaching materials in other regions with similar cultural diversity.

From the perspective of the Sustainable Development Goals (SDGs), this study contributes directly to SDG 4 (Quality Education) by providing a valid and reliable instrument that supports inclusive, equitable, and context-based mathematics education. By identifying students' learning needs before instructional materials are developed, the instrument enables teachers to design learning experiences that are more responsive to students' characteristics and learning preferences. Furthermore, integrating Sigi cultural ethnomathematics into the needs assessment process supports SDG 11 (Sustainable Cities and Communities) by promoting the preservation and transmission of local cultural knowledge through formal education. Thus, the developed instrument not only serves as an educational measurement tool but also provides a practical framework for strengthening culturally responsive mathematics education while supporting sustainable educational development.

CONCLUSION

Fundamental Finding: The study successfully developed student learning needs and characteristics instruments using the 4-D development model. Empirical testing confirmed that 17 of 26 questionnaire items and 11 of 15 interview questions were valid. The instruments also demonstrated good reliability, with coefficients of 0.786 for the questionnaire and 0.798 for the interview guideline. **Implication:** The validated and reliable instruments provide an evidence-based foundation for identifying students' learning needs and characteristics, enabling educators to design more responsive and culturally relevant mathematics instruction. The instruments support the development of Sigi cultural ethnomathematics-based teaching materials that contribute to the implementation of SDG 4 (Quality Education) by promoting inclusive, equitable, and context-based learning. Furthermore, by integrating local cultural knowledge into instructional planning, the instruments also support SDG 11 (Sustainable Cities and Communities) through the preservation and promotion of local cultural heritage within formal education. **Limitation:** The instrument validation and testing were conducted within a limited educational context, namely junior high schools in Sigi Regency. Additionally, several questionnaire and interview items were found to be invalid, indicating that the instrument may still require refinement before broader implementation. **Future Research:** Future studies should test the instruments in different regions, educational levels, and cultural contexts to enhance generalizability. Further research could also refine the invalid items, conduct larger-scale validation studies, and examine the effectiveness of using these instruments in developing ethnomathematics-based teaching materials and improving learning outcomes.

AUTHOR CONTRIBUTIONS

Mailili Wahyuni H contributed to the conceptualization of the study, research design, methodology development, instrument development, data collection, formal analysis, manuscript drafting, and project administration. **Jamhari Mohammad** contributed to the conceptual framework, supervision, validation, manuscript review and editing, and provided academic guidance throughout the research process. **Ratman** contributed to instrument validation, data interpretation, manuscript review and editing, and supervision. **Astija** contributed to data collection, visualization, validation, manuscript review and editing, and contributed to the dissemination of the research findings. All authors have read, reviewed, and approved the final version of the manuscript.

CONFLICT OF INTEREST STATEMENT

The authors state that no financial or personal conflicts of interest exist that may have affected the content or findings of this research.

STATEMENT ON THE USE OF AI OR DIGITAL TOOLS IN WRITING

The authors declare that no artificial intelligence (AI) tools or other digital writing assistants were used in the preparation, analysis, or writing of this manuscript. All stages of the research process, including data analysis, interpretation, and manuscript writing, were conducted solely by the authors. The authors take full responsibility for the originality, accuracy, and integrity of the content presented in this article.

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***Mailili Wahyuni H(Corresponding Author)**
Doctoral Program of Science Education, Faculty of Teacher Training and Education, Tadulako University;
Mathematics Education, Faculty of Teacher Training and Education, Alkhairaat University
Jl. Soekarno Hatta Km. 9, Mantikulore District, Palu City, Central Sulawesi 94148, Indonesia;
Jl. Diponegoro No. 39, Lere Village, West Palu District, Palu City, Central Sulawesi 94221, Indonesia
Email: nuning06match@gmail.com

Jamhari Mohammad
Doctoral Program of Science Education, Faculty of Teacher Training and Education, Tadulako University
Jl. Soekarno Hatta Km. 9, Mantikulore District, Palu City, Central Sulawesi 94148, Indonesia
Email: jamhari@untad.ac.id

Ratman
Doctoral Program of Science Education, Faculty of Teacher Training and Education, Tadulako University
Jl. Soekarno Hatta Km. 9, Mantikulore District, Palu City, Central Sulawesi 94148, Indonesia
Email: ratmanut@gmail.com

Astija
Doctoral Program of Science Education, Faculty of Teacher Training and Education, Tadulako University
Jl. Soekarno Hatta Km. 9, Mantikulore District, Palu City, Central Sulawesi 94148, Indonesia
Email: astijasurya@gmail.com