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Development of learning instruments based on ethnomathematics exploration of Kandaure Toraja motif oriented to numeracy skills

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Abstract: This study aims to develop learning tools based on ethnomathematics exploration through exploration of Tana Toraja kandaure motifs oriented to numeracy skills that are feasible and of high quality. The development model used in this research is the ADDIE development model. The sampling technique in this study used cluster sampling technique. The resulting product is an ethnomathematics-based learning device through exploration of Toraja kandaure motifs oriented to numeracy skills. The learning tools developed consist of teaching modules and online student worksheets. The research instrument consists of product validation sheets for material experts, media experts, and mathematics teachers, teacher product practicability questionnaires, student product practicability questionnaires, and learning implementation observation sheets, as well as pre-test and post-test. The analysis results showed that: Learning tools based on ethnomathematics exploration through exploration of Tana Toraja kandaure motifs oriented to numeracy skills developed have met the feasibility (validity) with an average validity score of 4.33 and interpretation of "Very Good"; (3) Learning tools developed have met the criteria of practicality with an average score of practicality questionnaires by students and teachers is 80.47%; (4) Learning tools improve students' numeracy skills with n-gain 0.48 and interpretation of "Medium".

Keywords:
Ethnomathematics, Learning instruments, Numeracy skill, Kandaure Toraja Motif

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1. Introduction

Education is one of the fundamental pillars of human existence. As defined by Ernest (1991), education can be understood as a process of knowledge transfer. The knowledge in question is not limited to theoretical understanding; it also encompasses practical skills and character development. In an educational setting, students are taught a range of subjects, including mathematics.

Mathematics is a significant field of study due to its capacity to cultivate logical thinking, systematic reasoning, and the ability to solve contextual and abstract problems. Nevertheless, mathematics is often regarded as a challenging subject. As Benacerraf & Putnam (1983), Hill et al. (2016), and Shapiro (1997) observe, the perception of mathematics as a dry, abstract, theoretical science replete with symbols and confusing formulas fosters a negative outlook

among students. One method of facilitating meaningful mathematical learning is the utilization of ethnomathematics-based learning tools. As defined by Gusfitri et al. (2022) and Opticia et al. (2022), learning tools are a set of materials, tools, media, instructions, and guidelines employed during the learning process. As postulated by Akker (2010), a learning tool may be considered of high quality if it exhibits three key attributes: validity, practicality, and effectiveness.

Ethnomathematics can be defined as the relationship between culture and mathematical aspects (D'Ambrosio, 1985, 2007; Rosa et al., 2016). It is recommended that students be introduced to ethnomathematics as a means of cultural preservation in Indonesia. The integration of cultural elements into mathematical learning, or vice versa, provides students, particularly those from regions where culture can flourish and where mathematical learning can be more engaging and meaningful (Ascher & D'Ambrosio, 1994; Prahmana & D'Ambrosio, 2020). The concept of numeracy can be observed from a multitude of cultural perspectives. Consequently, ethnomathematics-based learning of numeracy concepts is best approached from a cultural standpoint (Munthahana et al., 2023). Therefore, ethnomathematics-based learning of numeracy concepts is best approached from a cultural standpoint.

The term "numeracy skills" refers to the ability to apply number concepts and perform arithmetic operations in everyday life, as well as the capacity to interpret quantitative information (Grotlüschen et al., 2020; OECD, 2022; Steen, 2001). Numeracy skills are essential for enabling students to make informed decisions, solve real-life problems, and interpret data critically in various contexts (PIAAC, 2009). However, the level of numeracy in Indonesia is relatively low. This is corroborated by the national numeracy score for junior high school students or their equivalents, which reached only 40.63% in 2023 (OECD, 2023). Moreover, the results of the Program for International Student Assessment (PISA) from 2000 to 2022 show a similar pattern, with Indonesia tending to remain in a relatively static position in the PISA rankings (OECD, 2017). Indeed, Indonesia has experienced declines in mathematics proficiency scores on several occasions compared with the previous year. Furthermore, Indonesia's average mathematics score is consistently lower than the international average of 500.

This condition indicates that students still face difficulties in understanding and applying mathematical concepts in real-life contexts. Therefore, innovative learning approaches are needed to improve students' numeracy skills, particularly those that are meaningful and relevant to their daily experiences. Integrating ethnomathematics into learning, especially through culturally rich contexts such as the Kandaure Toraja motif, is expected to provide a contextual and engaging learning environment that can enhance students' numeracy development.

2. Methods

The research method employed is development research, otherwise known as Research and Development (R&D), utilizing the ADDIE model (Branch, 2009; Molenda, 2003). The study

population consisted of students enrolled in class seven of UPT SMP Negeri 1 Sangalla during the 2023/2024 academic year. The students were divided into three clusters, designated as VIIA, VIIB, and VIIC. A cluster sampling technique was employed to select the VIIC class, comprising 23 students, as the sample. The research was conducted during the second semester of the 2023/2024 academic year at UPT SMP Negeri 1 Sangalla.

The ADDIE model comprises five sequential processes: analysis, design, development, implementation, and evaluation. In this research, the analysis stage is divided into four phases: requirements analysis, curriculum and ethnomathematics analysis, students' characteristics analysis, and analysis of students' numeracy skills. The requirements analysis phase comprises observations and interviews with teachers to ascertain the need for product development. Furthermore, this analysis was conducted to ensure the product could be adapted to the specific conditions and facilities available at the school and among the student population. The curriculum and ethnomathematics analysis comprise the identification of learning objectives and their correlation with the Kandaure motif ethnomathematics. The analysis of students' characteristics is conducted through observation to identify the difficulties that students are experiencing. The analysis of students' numeracy skills involved observations and interviews with teachers at UPT SMP Negeri 1 Sangalla, particularly in grade seven.

At the design stage, researchers commenced the process of designing learning devices, beginning with the determination of the learning approach to be employed, the infrastructure to be utilized, the number of meetings to be held in the context of learning activities, the division of learning objectives according to the time allotted for their development, and the design of learning activities for the creation of teaching modules. Online student worksheets were employed, beginning with determining the Kandaure motif to be used, partitioning learning objectives across each worksheet, and designing activities to be incorporated into them. Additionally, methods for obtaining feedback on the learning devices were devised.

In the development stage, the designs created are transformed into learning-device products. The development stage encompasses the creation of teaching modules, the preparation of online student worksheets in Canva, the implementation of these worksheets on Liveworksheet, and the testing of the worksheets by researchers to verify each feature's functionality. Furthermore, the preparation of pre-test and post-test instruments, as well as other data collection instruments, including validation sheets, practicality questionnaires, and observation sheets, was conducted. Following the successful development of the product, researchers validated it with a materials reviewer, a media reviewer, and a UPT SMP Negeri 1 Sangalla mathematics teacher.

Following receipt of the reviewers' feedback, the research team revised the learning tools that had been developed. Subsequently, the product underwent an implementation or testing phase. A trial was conducted throughout seven meetings with VIIC students at UPT SMP Negeri 1 Sangalla. At this juncture, the researchers gathered data through the administration of a practicality questionnaire to teachers and students, the observation of sessions, and the administration of a pre-test and a post-test.

In the evaluation stage, the information and data obtained during this implementation stage are analyzed to draw conclusions about the product's quality across three aspects of assessment: validation, practicality, and product effectiveness. Subsequently, the data were subjected to quantitative analysis.

3. Results and Discussion

This development was conducted using the ADDIE development model. The ADDIE model comprises five processes: analysis, design, development, implementation, and evaluation. The development, as mentioned earlier, will subsequently yield a product, specifically a learning tool based on ethnomathematics and the exploration of Toraja kandaure motifs with a focus on numeracy skills.

The analysis stage is divided into four phases: requirements analysis, curriculum and ethnomathematics analysis, analysis of students' characteristics, and analysis of students' numeracy skills. In the requirements analysis section, the researchers identified a lack of active student participation in mathematical learning activities. A mere handful of students demonstrated active engagement in the learning process. Additionally, student enthusiasm is relatively low, as evidenced by the fact that a considerable number of students still perceive mathematics as a challenging subject. Furthermore, the school's teaching methodology is largely lecture-based, which often results in students lacking engagement and interest. Furthermore, the numeracy skills of students at the school are also found to be below average. Moreover, students at SMP Negeri 1 Sangalla demonstrate a familiarity with the surrounding cultural milieu. This is evidenced by the surrounding community’s continued adherence to prevailing cultural norms.

In an analysis of the curriculum and ethnomathematics, the researcher discovered that UPT SMP Negeri 1 Sangalla employs an independent curriculum. Furthermore, the researchers examined the learning outcomes of the phase D data analysis dimensions at the junior high school level, with a particular focus on class VII and its 17 learning objectives. The findings of this study will serve as a foundation for developing learning tools. The learning objectives that serve as the foundation for the development of learning tools are as follows: (1) Students can explain the meaning of data; (2) Students can demonstrate the population and sample of a data set; (3) Students can collect data to answer questions; (4) Students can present data in the form of tables and diagrams (bars, lines, and circles); (5) Students can analyze data to answer questions; (6) Students can solve contextual problems related to data analysis; (7) Students can communicate the results of data analysis that has been done; (8) Students can use tables to present and interpret data; (9) Students can use bar charts to present and interpret data; (10) Students can utilize line charts to present and interpret data; (11) Students can utilize pie charts to present and interpret data; (12) Students can collect samples that represent a population to obtain the necessary data; (13) Students can determine the mean of data to solve problems; (14) Students can determine the median of the data to solve problems; (15) Students can determine the mode of the data to solve problems; (16) Students can determine the range of the data to solve problems; (17) Students

can investigate the possibility of a change in the center measurement due to changes in data. At this phase, the researcher also undertook an analysis of the Kandaure motif to establish a connection with the material about data analysis. The researchers utilized kandaure motifs sourced from accessories provided by the educational institution.

Moreover, the researcher conducted direct observations of learning activities to gain a deeper understanding of the characteristics of the students. At this juncture, it became evident that a subset of students exhibited a dearth of confidence in articulating their work in the presence of the entire class. A mere handful of seventh-grade students engage actively in learning activities, particularly in the context of question-and-answer sessions. Moreover, some students exhibit difficulty in maintaining focus and attention during the instructor's presentation. Furthermore, most students possess smartphones, yet they primarily utilize them for gaming and social media. Only a small proportion of them utilize the device to access educational websites and resources, nor do they employ it to enhance their learning activities. Furthermore, students are acquainted with the cultural milieu in which they reside. This is attributable to the continued observance of the surrounding community of the cultural traditions in question.

To gain insight into the state of numeracy skills in UPT SMP Negeri 1 Sangalla, the researcher conducted interviews with teachers and undertook a review of the numeracy skills of students in the country. The findings revealed that students demonstrated a deficiency in their numeracy skills. This is because the students have only recently commenced their studies at the junior high school level, and the independent curriculum has only recently been implemented. This is evidenced by the persistently low level of competence demonstrated by students in achieving the numeracy indicators. Students demonstrate a deficiency in their ability to utilize established mathematical terminology to successfully resolve mathematical problems. Furthermore, students encounter difficulties in comprehending the information presented in the problem and reading and analyzing tables, diagrams, or other images, which impedes their ability to solve numeracy problems. Furthermore, students are not yet accustomed to solving problems that demand high levels of cognitive processing or those that necessitate drawing conclusions or making decisions based on existing information. Considering these circumstances, researcher have devised learning tools that are based on ethnomathematics and an exploration of Toraja kandaure motifs, with a particular focus on developing numeracy skills.

Following the completion of the analysis stage, the researcher proceeded to undertake the design stage for the development of learning device products. The design stage is undertaken with due consideration of the findings of the preceding analysis stage. At this juncture, the researchers proceed to devise a design for the learning device that is to be developed. The design comprises an approach to be employed, the facilities to be utilized, the time allotment, and the division of learning objectives at each meeting to compile teaching modules, design electronic student worksheets, and design instruments to obtain feedback related to the products developed. The instruments included validation sheets, practicality questionnaires, observation sheets, and pre-test and post-test.

The researcher elected to employ the scientific approach. This approach was selected to enhance students' capacity to identify mathematical concepts within the domain of ethnomathematics. Furthermore, students can be instructed in the practice of synthesizing their findings. Moreover, this approach is aligned with the subject matter to be taught, namely data analysis. This is because, following an analysis based on a literature review, the ethnomathematics of the Tana Toraja kandaure motif can be related to the material on data analysis. Subsequently, the researcher determines the necessary infrastructure to be employed. The infrastructure comprises a smartphone or computer, a projector, an internet network, Canva and LiveWorksheet, which are used to develop online student worksheets, and several other media, including PowerPoint, Menti.com, which is used for interactive presentations, Padlet, which is used for students reflection, and Google Form, which is used for assessment. Following a discussion with the teachers, it was agreed that the developed learning tools would be used in seven meetings, including a pre-test and a post-test.

Because of this decision, the researcher proceeded to subdivide the learning objectives by the number of sessions. Additionally, the researchers devised learning activities aligned with the materials and learning media that they had created. The design will then be developed into a learning module. Subsequently, the researcher devised the online student worksheets that would form part of the devised learning tools. This involved determining the kandaure motif to be used, dividing the learning objectives into each online student worksheets, and designing the activities for the online student worksheets. Additionally, the researchers designed data collection instruments, including validation sheets for material reviewer, media reviewer, and mathematics teachers; observation sheets for the implementation of learning activities; product practicality questionnaires for teachers and students; and pre-test and post-test instruments.

At the development stage, the researcher develops the previously prepared design into learning tools, which include teaching modules and online student worksheets. At this stage, the teaching modules are prepared, the Kandaure motifs are modeled, electronic student worksheets are created on Canva, and the online student worksheets are implemented on Liveworksheet. The online student worksheets are then tested by the researcher to ensure that each feature can be used correctly. At this juncture, the data collection instruments were also prepared, including validation sheets, questionnaires, and observation sheets for the implementation of learning activities, as well as pre-test and post-test. Following the successful completion of the product development phase, the researchers conducted a validation process involving the product's material reviewer, media reviewer, and a mathematics teacher from UPT SMP Negeri 1 Sangalla.

The researcher developed the teaching modules based on the learning outcomes, learning objectives, approaches utilized, time allocations provided, and designs that had been previously established. The development of the teaching modules includes the creation of general information, core components, as well as enrichment and remediation. Additionally, researchers have incorporated QR codes for important links that will be utilized in the learning activities. These links lead to various resources, including a Padlet space for student reflection,

an introductory media for data analysis material on Menti, electronic student worksheets, and links for the pre-test and post-test.

Subsequently, the researcher devised and collated four online student worksheets comprising three online student worksheets for group and one individual online student worksheets, using Canva. Subsequently, the outcomes of the preparatory phase were deployed on the LiveWorksheet platform. The website was populated with a variety of question formats, including multiple-choice, multiple-choice with multiple answers, line drawings, short form, and essays. Furthermore, the researcher entered the answer key by the previously established design. The following is an example of one of the online student worksheets that has been developed.

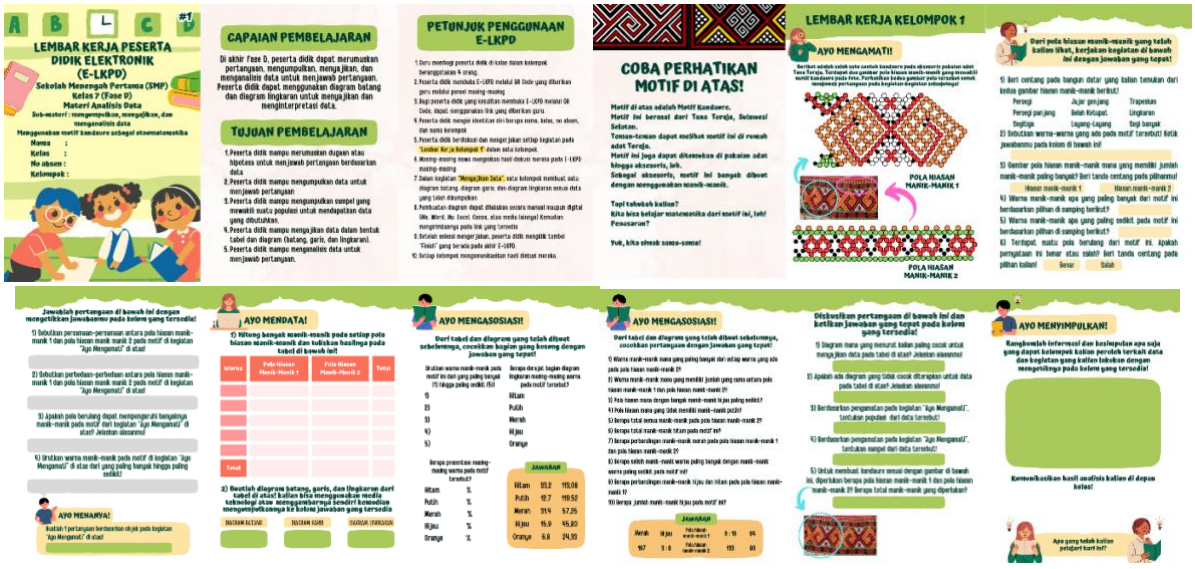

Figure 1. Online Student Worksheets

Later, the researcher developed data collection instruments based on the previously prepared grids. These instruments include validation sheets, observation sheets for implementing teaching modules, practicality questionnaires for students and teachers, and pre-test and post-test. The pre-test and post-test were each developed with 10 questions. Each test comprises four multiple-choice questions, two multiple-choice multiple-answer (MCMA) questions, two short fill-in questions, and one true-or-false question with two additional questions that assess the same content but with separate scores. Both tests are presented in the Google Form format.

Following the development of the learning tools, the researcher conducted a series of tests, with a particular focus on the online student worksheets, to ascertain that each feature could be utilized correctly. Additionally, the researcher evaluated the product with the supervisor to obtain feedback. Following the incorporation of feedback from the supervisor, the researchers conducted product validity tests with three validators: a material reviewer, a media reviewer, and UPT SMP Negeri 1 Sangalla mathematics teachers. The three reviewers concluded that the product could be employed with minor revisions.

Following the incorporation of feedback into the revised product, the researcher conducted a product trial with 23 VIIC-class students from UPT SMP Negeri 1 Sangalla. The

trial was conducted in a traditional, offline learning environment within the classroom setting, comprising seven meetings. These included one preliminary assessment meeting, five learning meetings, and a final post-test meeting. The learning activities were conducted according to the specifications outlined in the developed teaching module and utilized electronic student worksheets. Additionally, the researcher gathered data by completing observation sheets filled out by observers and practicality questionnaires completed by VIIC class students and UPT SMP Negeri 1 Sangalla mathematics teacher. Additionally, the researcher gathered data from the students' pre-test and post-test work conducted at the initial and final meetings, respectively. Subsequently, the data are subjected to analysis during the evaluation stage.

In the evaluation stage, the researcher will analyze the data collected. The data will be utilized as an evaluative measure of the quality of the learning tools employed. At this juncture, the research team analyzed the validation sheet to ascertain the quality of the product from the standpoint of validity, the product practicality questionnaire completed by teachers and students to determine the quality of the product from the perspective of practicality, and the numeracy pre-test and post-test to assess the quality of the product from the vantage point of effectiveness.

In the validity analysis, the researcher examined data from the product validation sheets completed by three reviewers. Each reviewer conducted validation tests on the teaching modules and online student worksheets. Each validation sheet was comprised of three aspects: content quality and objectives, instructional quality, and technical quality. The following table summarizes the teaching module validation results for each reviewer.

Table 1. Teaching Module Validation Results

Products	Reviewers	Validation results	Interpretation
Teaching Modules	Material Reviewer	4	Good
	Media Reviewer	3.88	Good
	Mathematics Teacher	4.86	Very Good
Average		4.25	Very Good

As illustrated in Table 1, the average validation score for the developed teaching module is 4.25, which is interpreted as "very good." Table 2 presents a recapitulation of the results of the online student worksheet validation from each reviewer.

Table 2. Online Student Worksheets Validation Results

Products	Reviewers	Validation results	Interpretation
Online Student Worksheets	Material Reviewer	4	Good
	Media Reviewer	4.08	Good
	Mathematics Teacher	4.78	Very Good
Average		4.29	Very Good

As shown in Table 2, the average validation score for the developed online student worksheet is 4.29, which is interpreted as "very good". By the two tables presented above, it

can be concluded that the average validation score of the learning tools developed is 4.27, which can be interpreted as "very good." It can thus be concluded that the learning device has met the validity criteria, which represent one of three quality criteria for learning devices, and is suitable for use in classroom learning activities.

In the practicality analysis, researchers employed a questionnaire distributed to students and teachers to assess the learning tool's practicality. A total of 23 students from Class VIIC completed the practicality questionnaire to determine the product's overall practicality. The teacher's product practicability questionnaire was completed by the mathematics teacher at UPT SMP Negeri 1 Sanggala. The following table summarizes the results of the practicality assessment conducted with teachers and students.

Table 3. Recapitulation of Product Practicability Questionnaire Results

Respondent	Average Persentation of Practition Product	Interpretation
Students class VIIC	77.03%	Practical
Mathematics Teacher	83.91%	Very Practical
Average	80.47%	Practical

As indicated in the table above, the percentage of product practicality, as determined by a student-completed questionnaire, is 77.03%, which is interpreted as "Practical." Furthermore, the percentage of product practicality, based on a teacher-completed questionnaire, is 83.91%, indicating that the product is "very practical." The overall average practicality of the product is thus 80.47%, which corresponds to the interpretation of "Practical." This demonstrates that the developed learning tools meet the practicality criterion, one of the three criteria for the quality of learning tools. They can therefore be readily employed by teacher and students alike.

In the effectiveness analysis, data were obtained from the pre- and post-tests administered to students. Both tests were designed to assess numeracy skills. The following table presents the results of the pre- and post-tests for students' numeracy skills.

Table 4. Results of Pre-Test Analysis of Students' Numeracy Skills

Class	Average of Post-test	Average of Post-test	Gain	Interpretation
VIIC	23.04	60	0.48	Medium

As shown in Table 4, the gain between the pre-test and post-test results is 0.48, which falls within the moderate range. This indicates an improvement in students' numeracy abilities, as evidenced by an increase in post-test scores from a pre-test average of 23.04 to 60. It can thus be concluded that the learning device developed has met the effectiveness criterion among the three quality criteria for learning devices and has demonstrated the capacity to improve students' numeracy skills.

Considering the explanations, it can be concluded that the learning tools based on ethnomathematical exploration of Tana Toraja kandaure motifs, oriented towards numeracy skills, have met the criteria of "valid," "practical," and "effective." This is consistent with

Nieveen's(1999) and Nieveen & Folmer's (2013) assertion that learning devices are considered high quality if they meet these three criteria. It can thus be concluded that the learning tools developed are of high quality and suitable for use in mathematics learning activities.

The findings of this study are consistent with previous research highlighting the effectiveness of ethnomathematics-based learning tools in improving students' mathematical understanding and engagement. For instance, studies have shown that integrating cultural contexts into mathematics learning can enhance conceptual understanding and make learning more meaningful for students (Husna et al., 2021; Rohaeti et al., 2020; Supriadi et al., 2023). This aligns with the present study, in which the incorporation of the Kandaure Toraja motif helped students connect mathematical concepts to real-life cultural experiences, thereby improving their numeracy skills. Similar results were reported in studies emphasizing that ethnomathematics fosters contextual learning and strengthens students' problem-solving abilities (Asnawi et al., 2022; Gunay & Takunyaci, 2023; Patmara et al., 2020; Suryawan et al., 2023).

Despite these contributions, this study has several limitations. The research was conducted in a single class at a single school, which may limit the generalizability of the findings. Additionally, the implementation was carried out in a relatively short duration, and the effectiveness was measured only through pre-test and post-test results. Future research is recommended to involve a larger and more diverse sample, apply the learning tools over a longer period, and explore other cultural contexts and technological platforms to further validate and expand the findings.

4. Conclusion

The results of the research analysis and discussion on the development of learning tools based on the ethnomathematics of the Tana Toraja kandaure motif, oriented toward numeracy skills, indicate that the products developed meet the criteria of validity, practicality, and effectiveness. In terms of validity, the mean score for the overall learning device was 4.27, which falls within the "very good" range of interpretation. In terms of practicality, the overall product practicality questionnaire yielded an average score of 80.47%, with a practicality questionnaire score of 83.91% from teachers, which falls within the "very practical" category. The product practicality questionnaire results from students yielded an average score of 77.03%, which is classified as "practical." In terms of effectiveness, the learning devices have been shown to enhance students' numeracy skills. This is evidenced by the n-gain score of 0.48, which falls within the "Moderate" category. Considering these findings, it can be concluded that the ethnomathematical learning tool based on the Tana Toraja kandaure motif, designed to enhance numeracy skills, is an effective and suitable educational resource.

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