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DESIGN OF A BANGGAI CULTURE-INTEGRATED PROJECT-BASED LEARNING MODEL IN A BLENDED LEARNING SETTING TO IMPROVE STUDENTS' MATH LITERACY

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Abstract: Students' mathematical literacy in Indonesian junior high schools remains a significant educational challenge, particularly in solving contextual problems and applying mathematical concepts to real-life situations. This study aimed to develop and evaluate a Banggai culture-based Project-Based Learning (PjBL) model implemented within a blended learning environment to enhance students' mathematical literacy. The research employed a Research and Development (R&D) approach conducted over a six-month period in Banggai Laut Regency and Banggai Islands Regency. The developed learning model integrates ethnomathematical elements, project-based activities, and online–offline learning modes within a coherent sequence of instructional phases. Data were collected through observations, questionnaires, interviews, documentation, and mathematical literacy tests. Expert validation and field trials indicated that the model met the criteria of validity and practicality. Effectiveness testing using an independent samples t-test revealed a statistically significant improvement in students' mathematical literacy compared to conventional learning models ($t = 2.73$, $p < 0.05$), with a moderate normalized gain score. These findings indicate that a culturally grounded PjBL model implemented through blended learning effectively supports meaningful and contextualized mathematics learning. This study contributes to the development of culturally based instructional models aimed at improving students' mathematical literacy in secondary education.

Keywords: mathematical literacy; project-based learning; ethnomathematics; blended learning; Banggai culture

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INTRODUCTION:

The low mathematical literacy of students is still the main problem in mathematics learning in Indonesia, especially at the junior high school level. Data from the Programme for International Student Assessment (PISA) initiated by the Organisation for Economic Co-operation and Development (OECD), a study to evaluate the education system followed by more than 70 countries around the world, shows that the mathematics ability graph of Indonesian students over the past 9 years has decreased. In 2015, the mathematics score of Indonesian students was at a score of 386, then decreased in 2018 to 379, then decreased again in 2022 to 366 from an average score of 472 [1]. Meanwhile, the results of the National Assessment released by the Ministry of Education and Culture (2024) also show that the average numeracy ability is still below 60.

The data is in line with the analysis of PISA & AKM results conducted by Ngala & Marsigit (2024), which stated that only 18% of Indonesian students achieve at least level 2 proficiency in mathematics, i.e. the ability to apply basic knowledge and skills in simple situations, while almost no Indonesian students achieve high achievement at level 5 or 6 (the ability to perform the most complex and innovative tasks, and being able to develop and implement new ideas). At the national level, the achievement of minimum numeracy competency for junior high school students is in the category of 40.63%. This fact shows that there are serious problems in mathematical literacy among Indonesian. The results of Atikah, et al's [2] research show that around 71% of Indonesian students are categorized as students with low mathematical skills, where most of them have difficulty in dealing with situations that require mathematical problem-solving skills. They are not able to work on arithmetic calculation problems that do not use decimal numbers or problems whose instructions are not well detailed.

One of the factors that affect students' low understanding of concepts is cognitive ability. Cognitive ability is a key factor in the success of mathematics learning [3], [4], [5] Therefore, in the theory of cognitivism, Piaget stated that the learning process must be adjusted to the stage of cognitive development that students go through. The higher the cognitive level of a person, the more organized and also the more abstract his way of thinking [6]. In teaching in schools, Brunner proposes that learning should include optimal experiences to be willing and able to learn as well as structuring knowledge for optimal understanding [7].

Based on the description above, it is necessary to develop a learning approach that is in accordance with the current needs of mathematics learning, namely an approach that is able to contextualize mathematical material in accordance with real life. One approach that can answer these challenges is ethnomathematics. Ethnomathematics is an approach used for learning mathematics with cultural media around students [8]. The concept of Ethnomathematics was first introduced by Ubiratan D'Ambrosio [9] as an effort to understand how various cultural groups develop unique ways of calculating, measuring, and understanding space and patterns. In line with this opinion, [10] stated that, "Ethnomathematics studies the cultural aspects of mathematics. It presents mathematical concepts of the school curriculum in a way in which these concepts are related to the students' cultural and daily experiences, thereby enhancing their abilities to elaborate meaningful connections and deepening their understanding of mathematics."

Banggai is one of the tribes that inhabit the Banggai, Banggai Islands, and Banggai Laut Regencies, not only has a long history as an influential kingdom, but also stores mathematical values in its cultural artifacts. Research by Lajiba and Sudarco shows that various geometric principles are reflected in traditional Banggai architecture, such as the trapezoidal shape on the pillars of the Kamali house, the rhombus motifs on the terrace bars, and the cylindrical tube structure on the Tinano Pillars.

In supporting the effective application of the Ethnomathematics approach, especially the Banggai Culture, the Project-Based Learning (PjBL) model is one of the very potential learning models. Project-Based Learning (PjBL) encourages students to be actively involved through real projects, emphasizing the importance of collaboration, problem-solving, and reflection, which are in line with 21st century competency development [7][11]. The Project Based Learning model can train students to achieve 21st century skills, such as critical thinking skills, problem-solving, communication, collaboration and creativity [12], [13]. Meanwhile, learning by utilizing the cultural context will make it easier for students to solve problems and make discoveries because the problems involve the environment around where students live [10][14].

Integrated Project Based Learning Model Ethnomathematics is a learning model that is urgently needed to achieve the main goal of mathematics learning, which is to enable students to be able and skilled in formulating, using, interpreting and understanding how mathematics benefits in various life contexts so that they can practically apply mathematics in their daily lives in the midst of the society where they live [15], [16]. It's just that the implementation of Ethnomathematics Integrated Project Based Learning has a number of challenges in its implementation, such as the need for time and high costs, dependence on learning media and resources, and the readiness of teachers and students to be active and collaborative [17], [18]. Along with the development of technology and the demands of 21st century skills, there is a need for a more flexible, adaptive, and efficient learning model [19], [20] This provides an opportunity for the application of the blended learning model, which is a combination of online and offline learning. This model provides time flexibility and wide learning access, and has been proven to increase learning effectiveness when designed appropriately [21][22]. Blended learning offers time flexibility, access to extensive learning resources, and independent learning opportunities [23], [24].

Research conducted by Kusuma et al [4] and Guliz Aydin & Osman Mutlu [5] shows that blended learning models integrated with ethnomathematical approaches are effective in improving mathematical problem-solving skills. Thus, the integration of ethnomathematics approaches and Project-Based Learning (PjBL) models within the framework of Blended Learning is an innovative strategy that can increase the effectiveness of mathematics learning. The synergy between online and offline activities in Blended Learning makes learning more flexible, directed, and meaningful. This strategy directly supports the main goal of mathematics learning, which is to enable students to formulate, use, and apply mathematical concepts in various real-life contexts [19], [25].

Based on the above opportunities and challenges, a new learning model design was developed, namely the Banggai Culture-based Project Based Learning Model in a Blended Learning setting. Therefore, this study aims to design, develop, and empirically test a Project-Based Learning (PjBL) model that integrates Banggai culture within a blended learning setting to improve junior high school students' mathematical literacy. Specifically, this research seeks to examine the validity, practicality, and effectiveness of the proposed learning model in facilitating students' ability to formulate, apply, and interpret mathematical concepts in meaningful real-life contexts. By grounding mathematical learning in local cultural practices and combining face-to-face and online learning environments, this study is expected to provide an innovative and contextually relevant instructional model that addresses the persistent problem of low mathematical literacy among Indonesian students.

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LITERATURE REVIEW AND METHODOLOGY:

This type of research is Research & Development (R&D) which aims to produce a Project-based Learning Model based on Banggai Culture in a Blended Learning setting. This research was carried out for 6 months, starting from June to December 2025. The research sites chosen were the Banggai Laut Regency and Banggai Islands Regency. The test subjects in this study are divided into several parts. First, for the initial stage trial subject called the Limited Trial which was carried out on 12 students of SMP Negeri 1 Banggai Laut. The results of the trial were then analyzed and discussed with experts, namely the Professor of Mathematics Education at the State University of Makassar, resulting in a change in the prototype of the Learning Model developed from 6 phases to 7 phases. Furthermore, another extensive trial was carried out on the students of SMP Negeri 2 Buko Selatan which amounted to 20 students. From the results of the extensive trial, a change in the Model Syntax was obtained into 8 phases, then Dissemination (Model Effectiveness Test) was carried out in 2 schools, namely SMP Negeri 1 Banggai Laut, SMP Negeri 2 Banggai Laut and SMP Negeri 3 Banggai Laut, with a total of 40 students. The stages of selecting the test subjects can be described as follows:

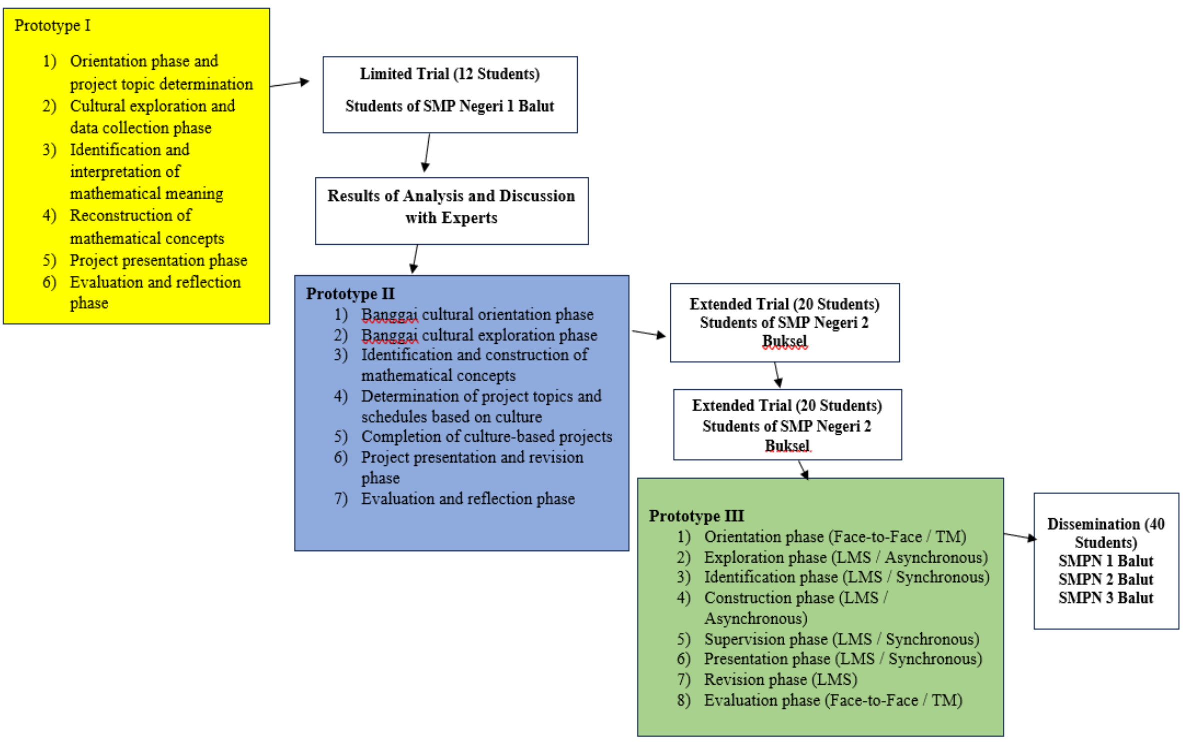

Figure 1. The stages of selecting the test subjects

The learning model development procedure in this study modifies 5 development models, namely the Plomp Model, ADDIE Model, Four-D Model, Dick and Carey Model and Borg & Gall Model, so that it becomes 4 stages that will be used, namely: (1) Preliminary Investigation, (2) Analysis, (3) Development and (4) Implementation (Implementation). The stages of the development procedure can be illustrated in the following chart:

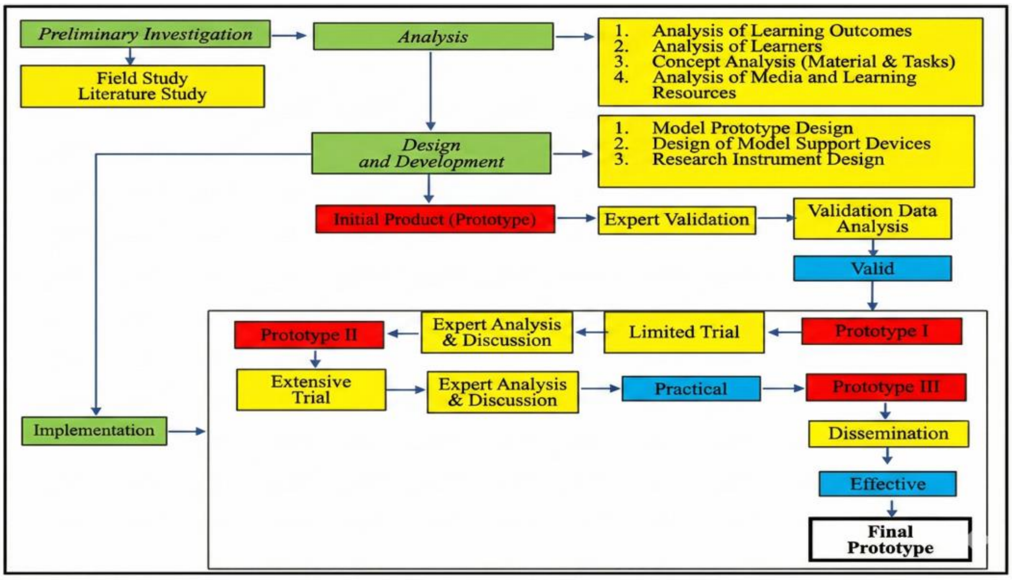

Figure 2. The stages of the development procedure

The data collection techniques used are observation, questionnaires, interviews, mathematical literacy ability tests and documentation. The data analysis used consisted of qualitative data analysis to analyze the results of Banggai cultural exploration, quantitative descriptive data analysis to calculate the average score of the teacher and student response questionnaire after experiencing learning with the developed model, and then inferential analysis to test the effectiveness of the developed learning model [26].

RESULTS AND THEIR ANALYSIS

Preliminary Investigation Results

At this stage, the activities carried out are to conduct needs and context analysis through field studies and literature studies. Field studies are carried out to identify problems that occur at school or in mathematics learning such as student learning outcomes, learning resources used, learning models used, learning media, and students' mathematical literacy skills. Based on the results of discussions with Mathematics teachers of SMP Negeri 1 Banggai Laut, information was obtained that the learning process is still centered on teachers. The Project Based Learning model has been used, but most students are not involved in learning activities. For Blended Learning itself, it has never been used, but students are asked to look for materials in mathematics books published by the Government through the internet. In addition, students' mathematical skills are also still very lacking, especially related to problem solving in daily life. This can be seen from the difficulty of students in working on non-routine questions or story problems. Similar information was conveyed by the mathematics teacher of SMP Negeri 2 Buko Selatan, Banggai Islands Regency, where grade VII students still have difficulty in working on problems in the form of story problems or problem solving, they have not been able to make mathematical models of the story problems.

On the other hand, the results of initial interviews conducted with junior high school students revealed information that mathematics teachers still apply less varied learning patterns. In general, teachers start by examining or discussing assignments, then delivering material and ending with assigning assignments again. This kind of learning pattern tends to reduce students' interest and interest in learning mathematics. Regarding the implementation of Banggai culture-based learning, no information has been obtained that mathematics teachers utilize or connect local culture in the mathematics learning process. In general, teachers only use materials contained in package books and student worksheets (LKPD) published by the Government. Even though the context of the material contained in the book and LKPD is not relevant or familiar with the activities experienced by students in daily life. This also makes it difficult for students to work on non-routine questions (story questions).

On the other hand, in the context of the Banggai tribe itself has a variety of cultures inherited from previous traditional societies, these cultures can be integrated in learning activities. This was revealed in a field study or initial investigation conducted in the form of interviews with Traditional and Cultural Leaders of Banggai Laut Regency and Banggai Islands Regency. Based on the results of the investigation, information was obtained that in general, Banggai culture is manifested in 3 aspects, namely the form of artifacts, the form of ideas and the form of activities.

Analysis Results

Based on the initial investigation carried out in the first stage, then an analysis was carried out. The analysis stage concerns three questions that must be answered completely. First, what competencies must be mastered by students after using the developed learning model? Second, what are the characteristics of students who will use this developed model? Third, in accordance with the required competencies and characteristics of students, what materials need to be developed? The third question is related to the analysis of the material in the form of subject matter, sub-sub-sections of the subject matter, also related to the situation of the task to apply the knowledge and skills learned. The results of the analysis related to the three important questions above can be stated as follows.

Learning Outcome Analysis Results

Based on the results of the needs analysis obtained from the initial investigation stage and the demands of the curriculum, it can be stated that the achievement in mathematics learning at the Junior High School Class VII level emphasizes more on mastery of high-level thinking skills, mathematical literacy, and a positive attitude towards mathematics learning.

Results of Student Characteristics Analysis

The students who were the subject of the model development trial were Junior High School (SMP) grade VII students in the Banggai Laut Regency and Banggai Islands Regency. In general, they are between 12 and 14 years old, being in the formal (early) operational stage according to Piaget's theory of cognitive development. The ethnic backgrounds of students are quite diverse, especially in urban areas. In several schools in Banggai City such as SMP Negeri 1 Banggai Laut and SMP Negeri 2 Banggai Laut, students come from various ethnicities, namely the Banggai Tribe (majority), Chinese, Bugis, Buton, and Gorontalo. Meanwhile, in the Banggai Islands Regency (Bangkep) area, most of the students come from the original Banggai Tribe. The language used in daily communication at school is Indonesian, although some students are still used to using the Banggai regional language in their home environment. These heterogeneous socio-cultural conditions are an important potential in ethnomathematics-based learning, as they allow students to discover the diversity of local cultural expressions and the value of togetherness in a mathematical context. The results of the initial pre-test showed that the average mathematical ability of students was still in the low category, especially in contextual problem solving. Most students are able to work on direct counting problems, but they have difficulty when faced with problems that require logical reasoning, analysis of inter-variable relationships, and the application of mathematical concepts in the context of daily life. The observation results showed that most students have visual and kinesthetic learning styles, which are easier to understand concepts if presented through pictures, practical activities, or concrete simulations. Students have basic skills using digital devices, such as mobile phones and the internet, but have not been systematically directed to learning activities. Therefore, the Blended Learning approach that combines face-to-face and online learning is assessed according to their characteristics.

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Results of Concept Analysis (Materials and Tasks)

Based on the results of the needs analysis, analysis of learning outcomes and analysis of student characteristics that have been carried out, the main material to be tested is the Integer material. Based on the analysis of learning outcomes, the Number element emphasizes the ability of students to understand, operate, and apply numbers in the context of daily life. In ethnomathematics-project-based learning, numbers are seen not only as mathematical entities, but also as symbolic representations of culture that appear in the social, economic, and local traditions of the Banggai people. From the analysis of the learning outcomes, it is then lowered into the flow of learning objectives so that the sub-sub-material of Integers appears, namely Positive & Negative Numbers, Integer Addition and Subtraction Operations, as well as integer multiplication and division operations.

Development Results

The results obtained at this stage are in the form of the development of an initial draft and expert validation results which include three things, namely (1) the Ethnomathematics Project-Based Blended Learning Model Draft and the results of expert validation of the model draft, (2) The Draft learning tool to support the implementation of the Blended Learning ModelBased on the Ethnomathematics Project and its validation results, as well as (3) Draft instruments that will be used to obtain the data needed in the development process and validation results. The results of the development of the Blended Learning Model book Based on Ethnomathematics Projects are determined in a Model book format which includes (1) Introduction, (2) Theoretical Framework, (3) Model Components, (4) Model Implementation Instructions, and (5) Assessment Format. Here's a draft of the resulting model book:

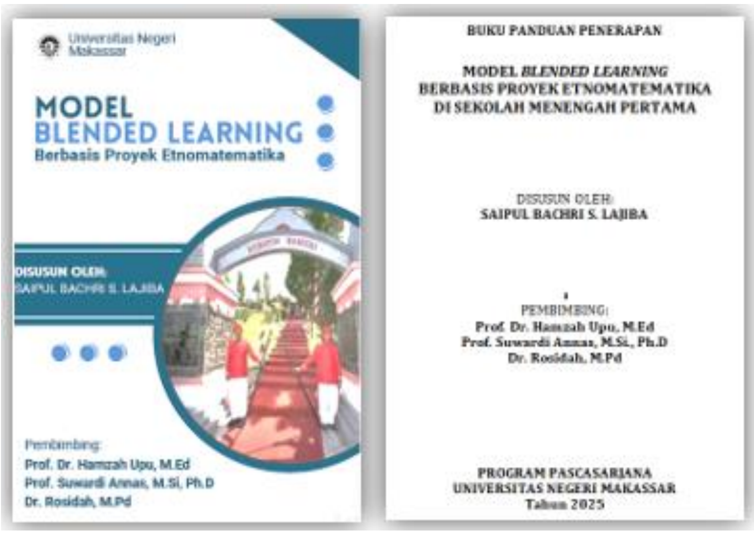

Figure 3. The Blended Learning Model Book

The Blended *Learning* Model Book Based on Ethnomathematics Projects was developed, then validated by two experts, namely Mr. **Prof. Dr. Abdul Rahman, M.Pd** as Validator I and Mr. **Dr. Muhammad Darwis, M.Si** as Validator II. This validation aims to provide assessments and suggestions on the Model Book that has been developed with a focus on Model Rationality, Supporting Theory, Syntax, Social System, Reaction Principles, Support System, Instructional and Accompanying Impacts, Learning Implementation Guidelines and Assessment Formats. The results of the Model book validation can be described in the following table.

Table 1. Validation Results of Learning Model Books

Rated components	Average Validation Results	Remarks
Model Rationality	3	Valid
Supporting Theories	3	Valid
Sintaks Model	3,5	Highly Valid
Social Systems	3	Valid
Reaction Principle	3,5	Highly Valid
Support Systems	3,125	Valid
Instructional and Companion Impacts	3	Valid
Learning Implementation Instructions	3,5	Highly Valid
Assessment Format	3,167	Valid
Overall average	**3,228**	**Valid**

From the data in the table, it can be seen that overall and each aspect of the assessment of the Ethnomathematics Project-Based *Blended Learning* Model in Junior High School has met the validity criteria, but there are still suggestions from experts that need to be considered for the perfection of the development of the model as in the following table.

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Table 2. Suggestions for improving Model Book Validation results

Rated components	**Suggestions/Feedback**
Model Rationality	*Blended learning* is enough to support *the flexibility of* learning time and increase students' digital literacy
Sintaks Model	In the learning model syntax section, add teacher activities and student activities
Supporting Theories	Add a theoretical foundation for model development
Support Systems	It is necessary to state in detail the support system used in *blended learning*
Assessment Format	Tailor assessment rubrics to developed math literacy skills

The learning tools used to support the implementation of the *Ethnomathematics Project-Based Blended Learning* Model include (1) Ethnomathematics-based Student Books or Integer Modules in the Banggai Cultural Context, (2) Ethnomathematics-based LKPD, and (3) RPP. The supporting tools for the implementation of the Ethnomathematics Project-Based *Blended Learning* Model were developed, then validated by two experts. This validation aims to provide assessments and suggestions on the Learning Tools that have been developed. The results of the validation of the learning tools can be described in the following table.

Table 3. Learning Tool Validation Results

Rated components	**Average Validation Results**	**Remarks**
A. Learning Modules		
1. Module Format and Components	3,5	Highly Valid
2. Module Contents	2,84	Valid
3. Language	3,5	Highly Valid
Overall average	**3,027**	**Valid**

B. LKPD		
1. Contents	3,33	Valid
2. Construct	3,12	Valid
Overall average	**3,18**	**Valid**
C. RPP		
1. Contents	3,5	Highly Valid
2. Construct	3	Valid
3. Selection of learning resources	4	Highly Valid
4. Selection and Organization of teaching materials	3,5	Highly Valid
5. Learning Scenarios	3	Valid
6. Assessments	3,5	Highly Valid
7. Language	3,5	Highly Valid
Overall Average	**3,35**	**Valid**

From the data in the table, it can be seen that overall aspects and each aspect of the assessment of Learning Tools in supporting the implementation of *the* Ethnomathematics Project-Based Blended Learning Model in Junior High Schools has met the validity criteria, but there are still suggestions from experts that need to be considered for the perfection of the development of the learning tool as in the following table.

Table 4. Suggestions for improving Learning Tool Validation results

Rated components	Suggestions/Feedback
Learning Modules	a. Add learning outcomes to each learning activity b. Complete module components by adding Exercises to each learning activity
Student Activity Sheet (LKPD)	a. The objectives in the LKPD are adjusted to those in the RPP b. Every problem, there must be a place to solve it
Learning Implementation Plan (RPP)	a. Add assessment rubrics and quiz questions along with the answer key b. In the learning material section, there must be a sub-subject c. The time allocation is divided into each phase d. Add a self-assessment tool

The supporting instruments used in the Development Process of the Ethnomathematics Project-Based Blended Learning Model include (1) Teacher response questionnaire to the implementation of the Ethnomathematics Project-Based Blended Learning Model, (2) Student response questionnaire to the Book or Learning Module, (3) Student response questionnaire to LKPD, (4) Observation Sheet on learning implementation using the Blended Learning ModelBased on the Ethnomathematics Project, and (5) Mathematics Literacy Ability Test. The supporting instruments for the development of the Blended Learning Model Based on the Ethnomathematics Project that were developed were then validated by two experts. The results of the validation of the supporting instruments can be described in the following table 5.

Table 5. Validation Results of Supporting Instruments

Rated components	Average Validation Results	Remarks
A. Teacher Response Questionnaire		
1. Aspects of Clues	4	Highly Valid
2. Language Aspects	3,5	Highly Valid
3. Content Aspect	3	Valid
Overall average	**3,36**	**Valid**
B. Student Response Questionnaire to Learning Modules		
1. Aspects of Clues	4	Highly Valid
2. Language Aspects	3,25	Valid
3. Content Aspect	3,2	Valid
Overall average	**3,36**	**Valid**
C. Student Response Questionnaire to LKPD		
1. Aspects of Clues	4	Highly Valid
2. Language Aspects	3,25	Valid
3. Content Aspect	3,2	Valid
Overall average	**3,36**	**Valid**

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D. Learning Implementation Observation Sheet		
1. Syntax of Learning Models	3,5	Highly Valid
2. Social Interaction	3	Valid
3. Reaction Principle	2,9	Valid
4. Instructional Impact and Companion Impact	2,5	Valid
5. Supporting learning tools	3,5	Highly Valid
Overall average	**3,14**	**Valid**
E. Mathematics Literacy Ability Test		
1. Contents	3,5	Highly Valid
2. Construct	3	Valid
Overall average	**3,22**	**Valid**

From the data in the table, it can be seen that overall and each aspect of the assessment of the Mathematical Literacy Ability Test instrument has met the validity criteria, but there are still suggestions from experts that need to be considered for the perfection of the development of the test instrument as in the following table.

Table 6. Suggestions for improving Test Instrument Validation results

Rated components	**Suggestions/Feedback**
Test Construction Number 1	Add the sentence "equally wide" to the construction of test number 1, and then replace the word "error in measurement" with "lack of seeds"
Test Construction Number 2	Change the wording of the sentence *"Make a number line that shows the time span between the governments and calculate the difference in years between each of the two kings in* a row!"to "*Show on the number line the length of the reign of each King in order!"* in question number 2
Test Construction Number 3	Replace the sentence *"due to extreme weather"* in question number 3, with the sentence *"because this year the number of family members has decreased"*

4. Implementation & Dissemination Results

The results obtained at this stage are in the form of the development of an initial draft and the results of the first revision based on the assessment of experts (validators). This stage consists of 3 activities, namely (a) limited trials, (b) extensive trials, and (c) effectiveness trials or product dissemination (Blended Learning Model based on Ethnomathematics Project) developed. The results of the limited trial showed that there were 4 students out of 12 students or 33% who had high mathematical literacy skills after learning using the blended learning model based on the Ethnomathematics Project, 3 students or 25% had moderate mathematical literacy skills. Meanwhile, 5 students or 41% are still in the low category. The presentation of mathematical literacy ability data in a bar graph can be seen in the following figure.

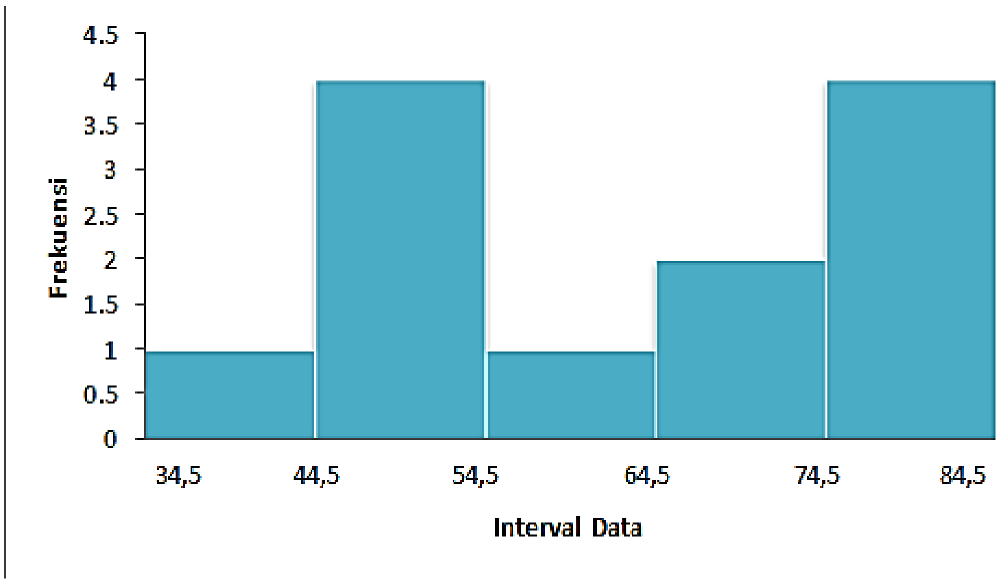

Figure 4. Mathematics Literacy Ability Data

Furthermore, a descriptive statistical calculation is carried out based on the data presented in the image above, and the results of statistical analysis are obtained as in the following table.

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Table 7. Descriptive Statistical Analysis of Limited Trial Results

Analysis Components	Analysis Results
Mean	62
Middle value (Median)	65
Frequently appearing values (Mode)	50
Standard Deviation	15.74802
Maximum Score	84
Score Minimum	35
Total Score	744
Number of Data (n)	12

The results of the extensive trial showed that there were 15 students out of 28 students or 54% who had high mathematical literacy skills after learning using the *Blended Learning model* based on the Ethnomathematics Project, 7 students or 25% had moderate mathematical literacy skills. Meanwhile, 6 students or 21% are still in the low category. The presentation of data on mathematical literacy ability can be seen in the following figure.

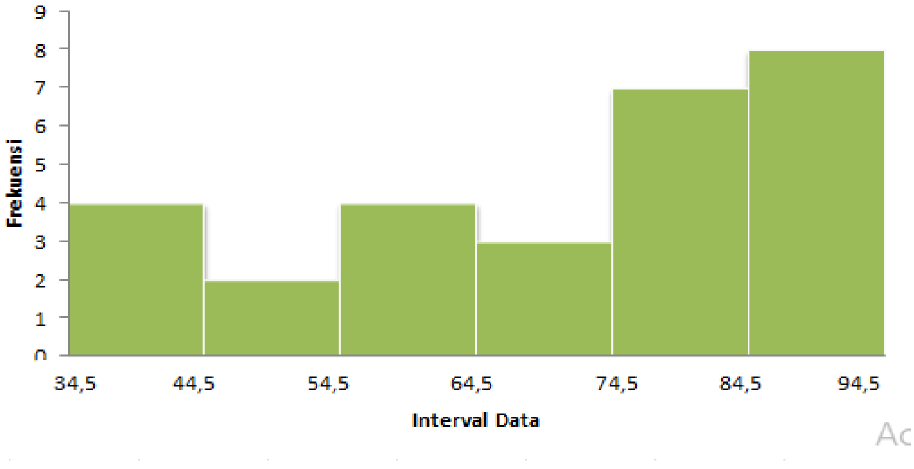

Figure 5. Mathematics Literacy Ability Data

Furthermore, a descriptive statistical calculation is carried out based on the data presented in the image above, and the results of statistical analysis are obtained as in the following table.

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Table 8. Descriptive Statistical Analysis of Extensive Trial Results

Analysis Components	Analysis Results
Mean	70
Middle value (Median)	70
Frequently appearing values (Mode)	80
Standard Deviation	19.46381122
Maximum Score	93
Score Minimum	35
Total Score	1971
Number of Data (n)	28

After descriptive data analysis, the analysis prerequisite test was then carried out, namely the normality and homogeneity test using inferential statistics. The normality test is used to find out whether the pretest and posttest data are normally distributed or not. In this study, the researcher used the Kolmogorov-Smirnov Test, because the sample used was > 30. The following are the results of the normality test on the pretest data for the experimental class, obtained a value of D calculated = 0.127 < D table = 0.229, as well as the value of p-value = 0.187 > $\alpha = 0.05$, this shows that there is no significant difference between the distribution of data and the normal distribution, then it can be concluded that the data is distributed normally. Furthermore, for the results of the posttest data normality test in the experimental class, the value of D calculated = 0.107 < Table D = 0.229, as well as the value of p-value = 0.5393 > $\alpha = 0.05$, this shows that there is no significant difference between the data distribution and the normal distribution, then it can be concluded that the data is normally distributed.

Next, for the results of the pretest data normality test in the control class, the value of D calculated = 0.197 < Table D = 0.229, as well as the p-value = 0.1161 > $\alpha = 0.05$, this shows that there is no significant difference between the data distribution and the normal distribution, then it can be concluded that the data is normally distributed. Meanwhile, for the results of the normality test of posttest data in the control class, the value of D calculated = 0.191 < D table = 0.229, as well as the value of p-value = 0.200 > $\alpha = 0.05$, this shows that there is no significant difference between the distribution of data and the normal distribution, then it can be concluded that the data is distributed normally.

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In addition to conducting a normality test, another prerequisite test is a homogeneity test which also uses inferential statistics. The data homogeneity test is used to find out whether the experimental class and control class data have the same/homogeneous variance or not. In this study, the researcher used the F Test because the data to be tested is normally distributed data. The homogeneity test results for the pretest data are shown in the following table.

Table 9. Homogeneity test of Pretest Data

	Experimental Classes	**Control Class**
Mean	42,1428	29,2857
Variance	229,5378	261,9748
Observations	55,0000	55,0000
Df	54,0000	54,0000
F	0,8761	
P(F<=f) one-tail	0.3510	
F Critical one-tail	0,5643	

The results of the above homogeneity test showed that the score variance between the experimental class (Mean = 42.14, Variance = 229.54) and the control class (Mean = 29.29, Variance = 261.97) did not differ significantly (F = 0.876, p = 0.351 > 0.05). This means that both groups have relatively the same (homogeneous) data dispersion rate, or in other words: The variance of the experimental class and control class data is homogeneous. Thus, the homogeneity assumption is fulfilled and the data is feasible to proceed to the t-test (independent sample t-test) using the t-Test Two-Sample Assuming Equal Variances. As for the posttest data, the test results are shown in table 10.

Table 10. Homogeneity test from Posttest Data

	Experimental Classes	**Control Class**
Mean	74,0857	67,5714
Variance	135,8453	63,7815
Observations	55,0000	55,0000
Df	54,0000	54,0000
F	2,1298	
P(F<=f) one-tail	0,0152	
F Critical one-tail	1,7720	

The results of the homogeneity test in the posttest data above showed that the variance of student learning outcomes in the experimental class (Mean = 74.09, Variance = 135.85) and the control class (Mean = 67.57, Variance = 63.78) differed significantly (F = 2.13, p = 0.015 < 0.05). This means that the spread of scores between the two groups is not the same (not homogeneous). Therefore, in the hypothesis test, t-Test Two-Sample Assuming Unequal Variances was used.

Furthermore, hypothesis testing was carried out using a two-sample t-test, with the aim of seeing the average difference between the mathematical literacy ability of students who applied learning with the Ethnomathematics Project-Based Blended Learning Model and the mathematical literacy ability of students who applied learning with the Problem Based Learning Model. Based on the results of the test, data was obtained as shown in the following table.

Table 11. Results of the t-test analysis of two independent samples

	Blended Learning *Model* based on Ethnomathematics Project	**Model *Problem Based Learning***
Mean	74,0857	67,5714
Variance	135,8453	63,7815
Observations	55,0000	55,0000
Hypothesized Mean Difference	0,0000	
Df	60,0000	
t Stat	2,7276	
P(T<=t) one-tail	0,0041	
t Critical one-tail	1,6706	
P(T<=t) two-tail	0,0083	
t Critical two-tail	2,0002	

Based on the results of the independent t-test with free degrees (df) = 60, the values of t = 2.73 and p = 0.008 (< 0.05) were obtained. These results show that there is a difference in the average mathematical literacy ability of students taught using the Blended Learning Model based on the Ethnomathematics Project and the Problem Based Learning Model. The average mathematical literacy ability of students taught using the Ethnomathematics Project-based Blended Learning Model (Mean = 74.09) was significantly higher than the average mathematical literacy ability of students taught using the Problem Based Learning Model (Mean = 67.57). Thus, it can be concluded that the Blended Learning Model based on the Ethnomathematics Project has proven to be effective in improving students' mathematical literacy skills.

The purpose of the normalized N-gain test is intended to provide an overview of students' mathematical literacy skills between before and after learning. The thermonormalized N-gain test recapitulation is described in the following table 4.52.

Table 12. Normalized N-Gain Test

	Experimental Classes	Control Class
Mean	0,57	0,53
Maximum	0,82	0,71
Minimum	0,28	0,29
Range	0,54	0,43
Median	0,56	0,57
Variance	0,02	0,01
Standard Deviation	0,15	0,10

Based on the data and criteria conducted in the experimental class, it can be concluded that the average N-Gain value is 0.57. This figure is in the medium category (because it is $0.3 \geq 0.57 \geq 0.7$), with a minimum score of 0.28 and a maximum score of 0.82. Thus, it can be concluded that overall, the Blended Learning Model based on the Ethnomathematics Project given to the experimental class is effective in improving students' mathematical literacy skills.

Discussion

The stages of developing the blended learning model based on the Ethnomathematics Project adapt the Plomp Model which is integrated with the ADDIE Model, Four-D Model, Dick & Carey Model and Borg & Gall Model so as to give birth to 4 stages of Model development, namely Preliminary Investigation, Analysis, Development and Implementation & Dissemination (Implementation and Dissemination). The four stages are described in the explanation as follows.

a. *Preliminary Investigation*

The results of the initial interviews with mathematics teachers showed that mathematics learning is still conventional, teachers still find it difficult to implement contextual-based or project-based learning. In practice, teachers only provide explanations of material based on government-issued package books obtained by students from internet pages, after which they provide examples of questions and exercises as well as assignments to be done at home. In addition, teachers have also never integrated mathematics learning with the cultural context or daily life activities experienced by students, as a result based on the mathematics teacher's narration, students have difficulty in working on contextual problems or story problems.

They have difficulty in formulating, using or interpreting mathematics into the context of daily life. [27] argues that such conventional learning models provide less space for students to explore and build conceptual understanding independently. As a result, students simply memorize the procedure without understanding the meaning behind the concepts being taught. It will also inhibit the formation of higher-level thinking skills, such as analysis, synthesis, and evaluation [28].

In fact, behind the difficulties in implementing contextual learning, each region has a variety of cultural contexts that can be integrated with learning, especially mathematics learning. Banggai is one of the tribes in Indonesia that is rich in cultural heritage. The existence of the Banggai Palace and several *kamali* houses (traditional houses), as well as various cultural activities of the past community that are still carried out today as well as ideas sourced from various traditions and stories of the past are evidence of the existence of a culture that continues to be maintained. This is one of the relevant learning resources to be integrated in mathematics learning.

Bishop mentioned that mathematics cannot be separated from the cultural context because every human activity such as calculating, measuring, designing, and explaining, always involves mathematical elements in some form. If mathematics learning in school does not pay attention to the cultural context, then students miss out on the opportunity to relate abstract concepts to their concrete experiences. The integration of cultural activities with the defense of mathematics in schools is called Ethnomathematics, which is a study of how certain cultural groups develop and use mathematical ideas in daily activities [29]. Furthermore, Rosa & Orey [30] also explained that the exploration of cultural activities and artifacts like this allows teachers and students to discover embedded mathematics, which is the mathematical principles, patterns, or structures contained in daily cultural practices. This approach enriches learning and makes mathematics more contextual, meaningful, and relevant to students' lives.

Another finding in this preliminary investigation stage was information from mathematics teachers that the use of the blended learning model in learning was not familiar. But on the other hand, students are asked to find learning resources (textbooks) through internet facilities to be able to learn independently. This fact actually reflects the 21st century learning tendency that demands self-directed learning and digital literacy skills. According to the OECD

[31], one of the important competencies of the 21st century is digital literacy, which is the ability to search, evaluate, and use information from various digital sources to solve problems and build knowledge. In the theory of Connectivism, it is explained that in the digital era, knowledge is spread across various information networks, and learning means building connections between these sources [25][32]

But the reality today is that teachers tend to use technology only as an administrative tool (e.g. sending assignments or materials), rather than as part of an interactive learning design. The results of the research by Putra & Sari [19], show that most teachers still use the digital platform in a one-way (teacher-centered), not to build active learning interactions. In fact, UNESCO [33] emphasizes that the experience of the Covid-19 pandemic should be a momentum to strengthen the transformation of digital pedagogy towards true blended learning, where teachers utilize technology to enrich learning, not just replace face-to-face learning.

Some studies have also shown that blended learning approaches are superior to traditional approaches because blended learning is interactive, provides large amounts of material and is tailored to different teaching styles [30], [34] Integrating ethnomathematics with project-based learning within the framework of a blended learning approach can be an alternative to overcome problems while meeting the needs of mathematics learning at the junior high school level. Therefore, this component is the basis for developing a draft of the Blended Learning Module based on the Ethnomathematics Project in junior high school.

b. Analysis

The results of the analysis of mathematics learning outcomes that must be possessed by students through the application of the Blended Learning Model based on the Ethnomathematics Project are directed to: (1) Develop conceptual understanding and mathematical literacy through the integration of the Banggai cultural context (cognitive realm). This is in line with the concept of Curriculum Learning and Assessment which emphasizes that mathematics learning outcomes at the junior high school level must be oriented towards mathematical reasoning competencies, conceptual understanding, and the application of mathematics in the context of real life; (2) Improve skills through local cultural integrated project activities that utilize digital media and collaborative activities (psychomotor domain).

The form of project-based learning activities is a learning activity that encourages students to design a systematic task (project) so that they learn knowledge and skills through a structured and complex process of searching/excavation (*inquiry*) then formulating and conducting a guidance and assessment process.

In the current learning context, the process requires the integration of digital technology so that learning can take place in a more flexible, collaborative, and authentic manner. Through a blended learning approach, project activities can be facilitated both face-to-face and online by utilizing various digital platforms such as *Google Classroom*, *Canva*, or *Zoom meetings* to support the design, documentation, and presentation of project results. The application *of blended learning* in project-based learning allows students to develop critical thinking, creativity, collaboration, and communication skills (4Cs) through the use of technology as a learning medium and a means of reflection on project results [35], [36] (3) Fostering positive attitudes and character through appreciation of local cultural values in mathematics learning (affective domain). In addition to having a positive influence, current technological advances also have an impact on the erosion of the attitudes and characters possessed by students. Culture-based learning is one of the strategies to internalize character values, such as brotherhood, unity and cooperation as well as a sense of responsibility in students [37], [38].

Furthermore, the results of the analysis of the characteristics of the students showed that the research subjects were in the age range of 12–14 years, which is the initial formal operational stage according to Jean Piaget's theory of cognitive development. At this stage, students begin to be able to think abstractly and logically, but their conceptual understanding still requires the support of concrete and contextual experiences. This means that in order for math concepts to be easier to understand, students need to be faced with real situations that are close to their lives. These findings are in line with the opinion of Woolfolk who states that in early adolescence, the most effective learning is one that connects abstract concepts with hands-on experiences that are meaningful to learners [20], [39] Cultural integration in mathematics learning is a bridge for the exploration of mathematical concepts that are relevant to students' lives. The results of the research of [9] also show that the integration of local cultural contexts in mathematics learning can increase student engagement and strengthen conceptual understanding, especially in junior high school students in areas with strong cultural backgrounds.

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The last phase in the analysis stage is concept analysis. Concept analysis is an important step in the development of a learning model because it determines the direction and structure of learning to be implemented. According to Majid [40] concept analysis aims to identify main ideas and sub-concepts that are relevant to learning outcomes so that learning takes place systematically and meaningfully. In the context of this research, the main concept or material studied is Integers, because this material is the foundation in understanding various other mathematical concepts such as algebra, measurement, and data. The selection of integer material is also supported by the results of Suryadi's [32] research which states that many junior high school students have difficulty in relating the concept of numbers to real situations because learning is still procedural and abstract. Therefore, the integration of the Banggai cultural context in number learning is expected to strengthen conceptual meaning through contextual learning experiences.

c. ***Development***

The prototype or initial product designed in the context of this research is the *Ethnomathematics Project-Based* Blended Learning Model Prototype.The framework of the *Blended Learning* learning model based on the Ethnomathematics integrated project refers to the components of the model proposed by Joyce, Weil & Shower [41], namely: a). Syntax, which is how the pattern of the sequence of student-teacher behavior is then called phases; b). Social system, namely the role of teachers and students and the types of rules needed in learning; c). The principle of reaction, namely how the teacher positions himself towards the students, for example in responding to questions from students; d). Supporting System, which is the condition required by the developed model; and e) Learning impact, namely how the expected learning outcomes and impacts are both instructional effects and nurturant effects.

In addition to the prototype of the Learning Model developed, in this stage learning tools and supporting instruments for the implementation of the Learning Model were also prepared. According to Dick & Carey [42] learning tools are developed to ensure that all learning components are interrelated and support the achievement of expected competencies. The learning tools developed include Learning Implementation Plans (RPP), Learning Modules and Student Worksheets. Meanwhile, the supporting instruments developed are instruments for observation sheets for learning implementation, questionnaires for student and teacher responses, and instruments for mathematical literacy ability tests. The instrument is a measurement tool used to obtain valid and reliable data on research variables [43].

Nieveen [44] also emphasized that good educational products must meet three main criteria, namely Valid, meaning consistent with the theory and needs of users; Practical, which means it can be used easily by teachers and students; and Effective, meaning able to improve learning outcomes or abilities to be achieved. Based on this, at this stage, a validity test is carried out on the prototype or model developed, learning tools and supporting instruments [45], [46].

d. *Implementation & Dissemination*

Limited trials were conducted to obtain an initial idea of the feasibility and practicality of the model before it was widely implemented. The results of the observations showed that the implementation of each phase of the model increased from meeting to meeting (average score of 3 to 4). This shows that teachers and students are able to follow the learning flow well after adjustments in some initial meetings. According to Joyce, Weil, & Calhoun [41], the successful implementation of the learning model is greatly influenced by the clarity of syntax and the role of the teacher as a facilitator. In this context, teachers play an important role in guiding students through the stages of cultural exploration to the construction of ethnomathematical projects. This success is also supported by the existence of other learning media and resources such as cultural videos and ethnomathematics-based learning modules that have been developed. With this media, teachers can easily provide contextual images to students related to their culture through the video screening of the story of Boine doi padang laya and the Banggai Lalango cultural site.Then from the cultural video, the teacher teaches the process of identifying and interpreting mathematical concepts as described in the learning module.

In large-scale trials, in general, the implementation of each component of the model (syntax, social systems, reaction principles, and support systems, as well as instructional & accompanying impacts) improved compared to limited trials. The syntax component achieves an average score of 3.75–4, indicating that the model is easier to implement after revision. Revisions to the syntax were carried out in the first phase of the Model, where students were first asked to study the ethnomathematics mobile module independently at home before learning directly at school (Asynchronous). The Mobile Ethnomathematics module used in this study is a supporting learning medium developed by researchers to make it easier for students to access materials and videos of proud culture through the play store. The above findings are in line with the opinion of Garrison & Vaughan [39], [47] who explained that in an inquiry community, which is one of the characteristics of Blended Learning, asynchronous activities allow students to reflect and explore ideas more deeply before interacting directly. In the results of Hwang, Lai, & Wang [48] research, it was also found that the use of mobile learning in asynchronous activities can increase students' readiness and motivation to learn, so that face-to-face activities focus more on in-depth discussions.

The results of the effectiveness test obtained an average posttest score of the experimental class of 74, which is a significant increase from the average pretest score of 42. While the control class only achieved an average posttest score of 68 out of a pretest score of 29). This shows that students' mathematical literacy skills in the experimental class are higher than those in the control class, which means that the Blended Learning Model based on the Ethnomathematics Project is effective in improving students' mathematical literacy skills.

CONCLUSION

Based on the results of the research and discussion, it can be concluded that the Banggai culture-based Project-Based Learning model in a blended learning setting was developed through four main stages: preliminary investigation, analysis, development, and implementation and dissemination. The resulting model prototype consists of eight learning phases, namely orientation, exploration, identification, construction, supervision, presentation, revision, evaluation, and reflection. The findings from expert validation and field trials indicate that the model is effective in improving students' mathematical literacy skills. Practically, this model is expected to offer a viable solution to the problem of low mathematical literacy in Indonesian junior high schools by providing meaningful, contextual, and culturally relevant learning experiences. The integration of local culture into mathematics learning also demonstrates the importance of connecting mathematical concepts with students' real-life environments to enhance understanding and engagement. For future research, further studies are recommended to investigate the long-term effects of this model on students' mathematical literacy and to explore its applicability across different cultural contexts and educational levels in Indonesia.

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