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Ethnomathematics Walewangko House in Project-Based Learning to Enhancing Students' Creative Thinking and Mathematical Disposition

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Abstract: This research aims to examine the effectiveness of Project-based Learning (PjBL) method based on ethnomathematics of Walewangko house on students' creative thinking skills and mathematical disposition. This study employed a quantitative approach with a quasi-experimental design. The sample consists of one experimental class with 34 eighth-grade students. The research instruments included pretests and posttests on creative thinking skills as well as a mathematical disposition questionnaire, both of which have been validated for reliability and validity. Data analysis comprised descriptive and inferential statistical analyses. The inferential statistical methods used were paired sample t-tests and one-sample t-tests. The results of this study indicated that: (1) there is an improvement in students' creative thinking skills and mathematical disposition before and after the learning method was applied, (2) the posttest results for creative thinking skills and mathematical disposition meet the respective standard scores, (3) the percentage of classical completeness in the posttest results for both creative thinking skills and mathematical disposition exceeds 85%. It can be concluded that the Project-Based Learning method based on the ethnomathematics of Walewangko house is effective in improving students' creative thinking skills and mathematical disposition. Integration of ethnomathematics as a basis for learning, in addition to acting as a contextual learning innovation, teachers are also expected to introduce and instill in students cultural values related to the ethnomathematics used.

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Introduction

Creative thinking skills are among the abilities expected to be developed in students through learning, including mathematics education. According to the Organization for Economic Cooperation and Development (OECD), organizations and societies worldwide are increasingly dependent on innovation and knowledge creation to address emerging challenges, thus emphasizing the urgency of innovation and creative thinking as a collective effort (OECD, 2019). It is also reflected in the inclusion of creative thinking skills as one of the assessment components in the study conducted by the OECD, namely the Programme for International Student Assessment (PISA). Critical and creative thinking skills help students solve problems in everyday life, and these skills can be developed through mathematics education (Purbaningrum & Mahmudi, 2024).

Several studies show that students' creative thinking skills are still in the poor or low category (Purwasih et al., 2018; Sahliawati & Nurlaelah, 2020). There are differences in creative thinking skills across school levels, with an adequate category at lower and higher-level schools and a poor category at middle-level schools (Arista & Mahmudi, 2020). Some of the causes of students' lack of creative thinking skills are that students are rarely given

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Jurnal Hasil Penelitian dan Kajian Kepustakaan di Bidang Pendidikan, Pengajaran dan Pembelajaran
https://e-journal.undikma.ac.id/index.php/jurnalkependidikan/index
Vol. 10, No. 4 : December 2024
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pp. 1584-1595
Email: jklppm@undikma.ac.id

non-routine questions and are accustomed to using one method of solving problems with a single answer (Medyasari et al., 2022), low disposition of students to think creatively due to learning that does not involve students actively, teacher-centered learning, rarely allowed to build basic concepts (Purwasih et al., 2018; Rusimamto et al., 2019), and students are not accustomed to and are not trained to develop creative thinking skills through learning and problem solving (Istiqomah et al., 2018).

The questions in the PISA study consist of numeracy and mathematical literacy questions. These questions require creative thinking skills to solve them (Shafa et al., 2023). This assessment evaluates students' ability to use mathematical principles to solve everyday problems. The 2022 PISA study shows that Indonesian students' math scores are still below the international average (OECD, 2023). Only 18% of Indonesian students achieved at least level 2 proficiency in mathematics, while almost no Indonesian students attained high achievement at levels 5 or 6. At the national level, the the Minimum Competency Assessment (AKM) shows that the achievement of minimum numeracy competencies for junior high school students nationally in 2022 is in the moderate category with a percentage of 40.63%, up 3.79% from the results in 2021 which were in the poor category with a percentage of 36.84%. (Kemendikbud, 2023). The results of the PISA study and the AKM results indicate that students' mathematical literacy skills still require attention for improvement.

One of the effective aspects that benefits students' mathematical ability acquisition is mathematical disposition. Mathematical disposition is an important aspect of achieving mathematics learning outcomes (Sansome, 2016). Mathematical disposition is the attitudinal tendency to regard mathematics as something that has meaning and value, to believe that success in learning mathematics can be obtained by hard effort in learning, and to have confidence in one's ability to become an effective learner and user of mathematics (Haryanti & Wijaya, 2023). Several studies show that students' mathematical disposition is still relatively low (Haryanti & Wijaya, 2023), and some are classified as moderate (Lestari et al., 2019). Mood and effective workload are one of the causes of students' low mathematical disposition (Utami et al., 2021). Low mathematical disposition is a reflection that students view mathematics as a difficult subject, and it negatively affects their learning process and results (Ulya & Rahayu, 2021).

One solution to address the above issues is through education, including selecting appropriate student-centered learning methods that focus on concept discovery (Haryanti & Wijaya, 2023). Project-based learning (PjBL) is one method that can be used as a solution. The PjBL method is one of the problem-based learning methods centered on students solving real and open problems and constructing and acquiring knowledge through group performance in making projects in the form of products. Several studies have shown that PjBL has a positive impact and encourages an increase in students' mathematical abilities, especially students' creative thinking skills and mathematical disposition (Barak & Yuan, 2021). PjBL can be implemented with the following steps: asking essential questions, designing project plans, designing activity schedules, monitoring learners and project progress, assessing work, and reflecting (Al-Tabany, 2017).

One of the causes of students' lack of ability to solve daily life problems such as in PISA and AKM is because learning does not connect mathematical concepts with real life (Maryati & Prahmana, 2019). Connecting mathematics to students' daily lives will foster their mathematical disposition. Ethnomathematics is one of the contextual learning related to the surrounding culture. From the perspective of education, ethnomathematics is about how to learn mathematics using cultural context. Ethnomathematics provides mathematical experiences that are connected to students' culture and life experiences will encourage the development of students' positive mathematical identities and self-confidence in their ability to make meaningful contributions, giving them agency as capable learners and practitioners of mathematics (NCTM, 2024). One of the ethnomathematics objects in Indonesia is the traditional house of the Minahasa tribe in North Sulawesi province known as the Walewangko house. One of the school mathematics concepts that is relevant to the Walewangko house is the material of flat-sided spatial figures. The parts of the house that form this traditional house can be explored in terms of spatial figures. Therefore, the researcher views that the use of ethnomathematics Walewangko house in the PjBL method is relevant to be applied.

This study integrates Walewangko home ethnomathematics as a basis in the project-based learning method to improve students' creative thinking skills and mathematical dispositions. This is the novelty of this study because researchers have not found other research that uses the context of Walewangko house ethnomathematics to improve students' creative thinking skills and mathematical dispositions. This study also aims to examine the effectiveness of the project-based learning method based on Walewangko home ethnomathematics on students' creative thinking skills and mathematical dispositions.

Research Method

This study used a quasi-experimental method with a quantitative approach because the researcher did not create an experimental group independently in terms of student selection (Cresswell, 2012). The research design used is a one-group pretest-posttest design because it uses one treatment group by giving pretests and posttests (Sugiyono, 2019). This research was conducted in 2 meetings for pretest and posttest administration, and 5 meetings for learning. The research sample was 34 students from one of the VIII grades of the 2023/2024 academic year at SMP Negeri 1 Tomohon, North Sulawesi province, who were selected using a purposive sampling technique. Data collection techniques were in the form of written tests, questionnaires, and documentation. The data collection instruments used were test instruments consisting of 4 pretest essay questions and 4 posttest essay questions to measure creative thinking skills, as well as non-test instruments, namely questionnaires consisting of 30 statement items to measure students' mathematical dispositions.

The indicators of creative thinking used are fluency, flexibility, originality, and elaboration (Almeida et al., 2008). For the mathematical disposition instrument, the indicators were adapted from Putra et al. (2017) and include self-confidence, flexibility, interest, curiosity, persistence and perseverance, self-reflection, and assessment or appreciation of mathematics. The instruments for assessing students' creative thinking skills and mathematical disposition have been validated by two experts. The results of expert validation were analyzed using the Gregory index and interpreted using the validity categories adapted from Retnawati (2016). In summary, each test instrument demonstrated high validity and was deemed suitable for use. Before use, these instruments were tested on 35 students, and reliability was estimated using Cronbach's alpha. The reliability estimates showed an alpha coefficient of 0.7 for the pretest, 0.72 for the posttest, and 0.86 for the mathematical disposition questionnaire. Nitko & Brookhart (2011, p. 81) state that an instrument is considered reliable if the reliability estimate reaches 0.65. Thus, the creative thinking ability instrument and the mathematical disposition questionnaire used are reliable.

Data were analyzed using descriptive and inferential statistics. The maximum total score obtained was 48, and then converted into a score with a scale of 1-100. The Minimum Completeness Criteria (KKM) as the standard of individual completeness value used was 75.

The scores obtained were then described using a qualitative scale as in Table 1 using the following formula according to the Tim Direktorat Pembinaan SMP (2017):

Length of score interval = (maximum skor – KKM value) : 3 (1)

Table 1. Category of Creative Thinking Skills Score

Score Interval	Categories
$X \geq 91$	Very high
$83 \leq X < 91$	High
$75 \leq X < 83$	Medium
$X < 75$	Low

For mathematical disposition, the maximum score was 120 and the minimum score was 30. Students' mathematical disposition scores would be interpreted based on the categories adapted from Widoyoko (2017) as follows:

Table 2. Category of Mathematical Disposition Score

Score Interval	Categories
$102 < X \leq 120$	Very high
$84 < X \leq 102$	High
$66 < X \leq 84$	Medium
$48 < X \leq 66$	Low
$X \leq 48$	Very low

The criteria for the effectiveness of the Project-Based Learning method based on the ethnomathematics of the Walewangko house in this study are: (1) there is an increase in students' creative thinking skills and mathematical disposition before and after the treatment of learning methods; (2) the average of creative thinking skills reaches the Minimum Completion Criteria (KKM), that is ≥75; (3) the percentage of students' classical completeness for creative thinking skills is at least 85%; (4) the average of mathematical disposition reaches the minimum score in the high category, that is ≥84; (5) the percentage of students' classical completeness for mathematical disposition is at least 85%.

Descriptive data analysis was conducted to test criteria (3) and (5). A study group is said to have completed its learning (classical completeness) if ≥85% of students in the class have completed it individually (Trianto, 2009). Students are individually complete if the creative thinking skills test score reaches the KKM 75. For mathematical disposition, students are individually complete if the mathematical disposition score reaches the minimum score in the high category, namely 84.

Inferential statistical data analysis was conducted to test criteria (1), (2) and (4). Criterion (1) was tested using a paired sample t-test. The hypothesis tested was :

H_0 : there is no increase in creative thinking skills and mathematical disposition before and after treatment

H_1 : there is an increase in creative thinking skills and mathematical disposition before and after treatment.

If the p-value <0.05 then H_0 is rejected.

Criteria (2) and (4) were tested for effectiveness against the standardized scores for each variable using a one-sample t-test. The hypothesis tested for criterion (2) is: H_0: $\mu_1 \leq 74.99$ and H_1: $\mu_1 > 74.99$. The hypothesis tested for criterion (4) is: H_0: $\mu_2 \leq 83.99$ and H_1: $\mu_2 > 83.99$. Where μ_1 is the average posttest score for creative thinking skills, and μ_2 is the average posttest score for mathematical disposition after treatment. If the p-value < 0.05, then H_0 is rejected. Before conducting inferential statistical analysis, the data collected were tested for normality using the Shapiro-Wilk test. If the p-value > 0.05, then the data are considered normally distributed (Hui, 2019).

Jurnal Kependidikan:
Jurnal Hasil Penelitian dan Kajian Kepustakaan di Bidang Pendidikan, Pengajaran dan Pembelajaran
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Vol. 10, No. 4 : December 2024
E-ISSN: 2442-7667
pp. 1584-1595
Email: jklppm@undikma.ac.id

Results and Discussion

Application of Project-Based Learning Based on Ethnomathematics Walewangko House

This study was conducted to examine the effectiveness of the Project-based Learning (PjBL) method, based on the ethnomathematics of the Walewangko house, on students' creative thinking skills and mathematical disposition. In this study, the project that students worked on was a simple miniature of the Walewangko house, composed of parts in the form of flat-sided space shapes. Projects in Project-based Learning are part of the learning process, not just something that occurs at the end of the learning (SEAQIL's Team, 2020). The ethnomathematics of the Walewangko house serve as a learning innovation, using the cultural context of the Minahasa traditional house as a starting point and as a context that facilitates students in terms of the mathematization process that exists and develops within the Minahasa people.

The application of this learning in this study also faces challenges in selecting projects that can support the achievement of learning objectives, as well as in allocating the available learning time for completing the project. According to Guo et al. (2020), the difficulties in PjBL are related to the need for more time allocation and the provision of tools and materials. To address the time allocation problem, the solution is to efficiently group materials and projects for each meeting. Since the amount of material for each meeting is kept minimal, the teacher sets the minimum learning objectives that must be achieved at each session. For the challenge of providing tools and materials, the solution applied in this study is for students to use cardboard and other tools provided by the teacher.

Mathematization is divided into two types: horizontal mathematization and vertical mathematization (A. Wijaya, 2012). Horizontal mathematization involves transforming contextual problems into mathematical forms. Through the project activity of creating miniatures, students relate the shapes of objects or parts of the Walewangko house to the concept of spatial geometry, drawing on their experience and knowledge of the ethnomathematical context of the Walewangko house. This process is implemented during the PjBL step of project planning and designing an activity schedule.

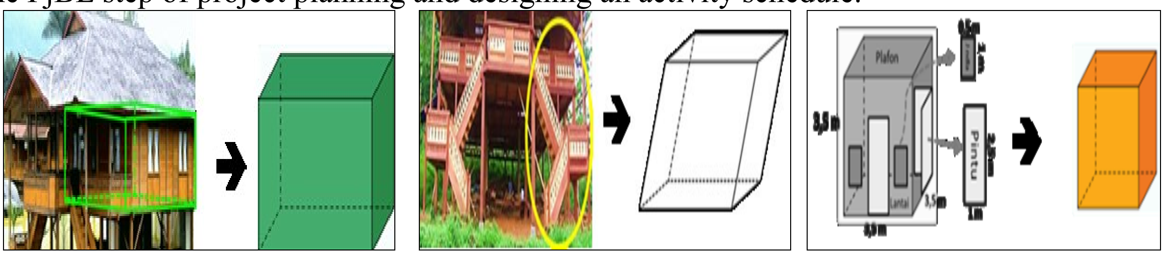

Figure 1. Example of Horizontal Mathematization

Vertical mathematization is the process of manipulating or restructuring existing mathematical concepts based on the relationship between existing concepts to obtain more formal and abstract results. Students move to a more abstract stage from geometric symbols/forms to abstract mathematics related to the elements and properties, surface area, and volume of each building. Through working on miniature projects in learning, the mathematization process from the ethnomathematics of the walewangko house into formal mathematics, for example, the surface area of the block-shaped part of the house, can involve students by identifying how local ways from the community calculate surface area. Through ethnomathematics, students solve problems through a horizontal mathematization process (Herawaty et al., 2018). In PjBL, this process is implemented in the steps of monitoring students and project progress, assessing work results, and reflection.

Vol. 10, No. 4 : December 2024
E-ISSN: 2442-7667
pp. 1584-1595
Email: jklppm@undikma.ac.id

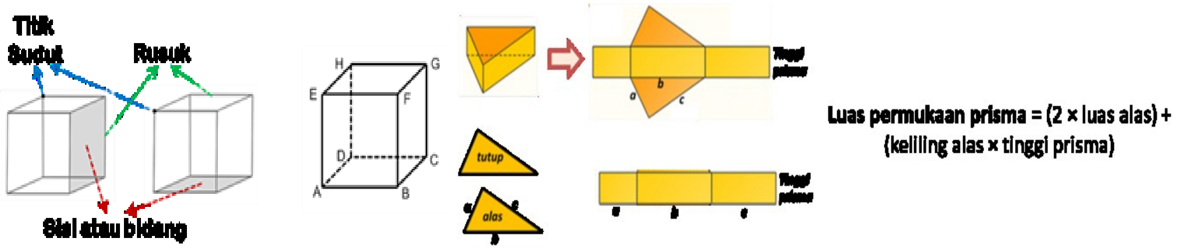

Figure 2. Example of Vertical Mathematization

Results of the Application of Project-Based Learning Based on Ethnomathematics of Walewangko House

After the learning was applied, the data that had been collected through the measurement results was then analyzed to find out how the effectiveness of the learning has been applied in accordance with the research objectives. The following are the results of descriptive statistics of creative thinking skills and mathematical disposition.

Table 3. Descriptive Statistics of Research Data

Descriptive Statistics	Creative Thinking Skills		Mathematical Disposition	
	Pretest	*Posttest*	*Pretest*	*Posttest*
Minimum Score	21	63	60	69
Maksimum Score	58	98	96	111
Average	35,18	83,82	80,12	88,85
Standard Deviation	9,56	8,28	7,92	8,27
Variance	91,39	68,56	62,73	68,39

From Table 3, it shows that the average pretest of creative thinking ability is in the low category, while the posttest of creative thinking is in the high category. In mathematical disposition, the pretest is in the medium category and posttest is in the high category.

Table 4. Classical Completeness and Achievement of Creative Thinking Skills

Description	Pretest		Posttest	
	f	%	f	%
Very High Category	0	0%	7	20,6%
High Category	0	0%	14	41,2%
Medium Category	0	0%	9	26,5%
Low Category	34	100%	4	11,8%
Students Completed	0	0%	30	88,2%
Students Not Completed	34	100%	4	11,8%

Table 5. Classical Completeness and Achievement of Mathematical Disposition

Description	Pretest		Posttest	
	f	%	f	%
Very High Category	0	0%	2	5,9%
High Category	8	23,5%	28	82,3%
Medium Category	24	70,6%	4	11,8%
Low Category	2	5,9%	0	0
Very Low Category	0	0%	0	0%
Students Completed	8	23,5%	30	88,2%
Students Not Completed	26	76,5%	4	11,8%

In Table 4, the percentage of classical completeness of the creative thinking skills posttest reached 88.2%, so it met the criteria for classical completeness for creative thinking skills. In Table 5, the percentage of students' mathematical disposition posttest classical completeness in the class reached 88.2%, so it met the criteria for classical completeness for mathematical

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https://e-journal.undikma.ac.id/index.php/jurnalkependidikan/index
Vol. 10, No. 4 : December 2024
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pp. 1584-1595
Email: jklppm@undikma.ac.id

disposition. The average and increase of each indicator are presented in Table 6 and Table 7 below.

Table 6. Average and Increase of Each Indicator of Creative Thinking Skills

Indicator	Max. Score	Pretest	Posttest	Increase and percentage
Flexibility	8	3,03	5,88	2,85 (35,6%)
Originality	16	5,35	12,62	7,27 (45,4%)
Fluency	8	2,76	7,53	4,77 (59,6%)
Elaboration	16	5,74	14,18	8,44 (52,6%)
Overall Average		35,18	83,82	48,64 (48,64%)

Table 7. Average and Increase of Each Indicator of Mathematical Disposition

Indicator	Max. – Min. Ideal Score	Pretest	Posttest	Increase and percentage
Self-Confidence	21	16,68	20,26	3,58 (17,0%)
Flexibility	9	7,32	7,97	0,65 (7,2%)
Interest	12	10,53	11,44	0,91 (7,6%)
Curiosity	6	5,06	5,71	0,65 (10,8%)
Persistence and Perseverance	12	10	10,91	0,91 (7,6%)
Self-Reflection	12	12,12	12,68	0,56 (4,7%)
Assessment or appreciation of mathematics	18	18,41	19,88	1,47 (8,2%)
Overall Average	90	80,12	88,85	8,73 (9,7%)

The data obtained were also analyzed by inferential statistics. Normality test as a prerequisite test using Shapiro-wilk test was conducted. The result showed that each data tested with the Shapiro-Wilk test obtained a p-value >0.05 so the data was normally distributed. Hypothesis testing for criteria (1), (2), and (4) was conducted using the RStudio application.

Table 8. Results of Hypothesis Test

Effectiveness Criteria	Type of Test	p-value	Conclusion
(1) average increase of pretest and posttest	Paired sample t-test	2.2e-16	H_0 rejected
(2) the average of creative thinking posttest reached KKM 75	One sample t-test	2.53e-07	H_0 rejected
(4) the average of mathematical disposition posttest reached a score of 84	One sample t-test	0.0008	H_0 rejected

The hypothesis test showed that there is an increase in creative thinking skills and mathematical disposition before and after treatment. The test results showed that the average posttest of creative thinking skills reached the KKM 75 and the average mathematical disposition after treatment reached the minimum score in the high category, which was 84. Thus, the effectiveness criteria (1), (2), and (4) have been met, and it can be concluded that the project-based learning method based on the ethnomathematics of the walewangko house is effective on students' creative thinking skills and mathematical disposition.

The results of this study are reinforced by the results of research which also concluded that the application of Project-Based Learning in the classroom can also optimize the improvement of students' creative thinking skills (Chen et al., 2019; Widana & Septiari, 2021). In addition, according to Astutiningtyas (2017), ethnomathematics has a positive impact on students' creative thinking skills. Ethnomathematics is the basis of contextualized learning which also has an important role in achieving the results of this study. This real-world application of knowledge and skills ensures a deeper understanding and retention of concepts, thus promoting creativity and active learning (Guo et al., 2020; Yu, 2024). Although separate, the results of these studies reinforce the findings in this study that the

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Jurnal Hasil Penelitian dan Kajian Kepustakaan
di Bidang Pendidikan, Pengajaran dan Pembelajaran
https://e-journal.undikma.ac.id/index.php/jurnalkependidikan/index
Vol. 10, No. 4 : December 2024
E-ISSN: 2442-7667
pp. 1584-1595
Email: jklppm@undikma.ac.id

collaboration between the Project-Based Learning method and the ethnomathematics of Walewangko house as a learning base is effective on students' creative thinking skills.

This learning activity contributes to students' creative thinking skills. Students are allowed to discover and understand the concept of flat-sided spatial structures independently through the creation of a project based on Walewangko house ethnomathematics. The process of creation through working on this project encourages students to work together to find solutions to authentic problems in the process of integration, application, and construction of knowledge (Chen et al., 2019; Guo et al., 2020; T. T. Wijaya et al., 2021). This activity stimulates students to think, apply, and convey different ideas from the time they plan to work on the project. In this study, a major increase was in the fluency indicator of 59.6%, which is related to students' ability to produce more than one answer or solution. It is due to students' better understanding of concepts because they experience direct learning experiences related to the material learned through the projects carried out. In PjBL, knowledge construction is also actively obtained based on the social context (group), which influences their ability to elaborate or describe information that forms the basis for knowledge construction (Biazus & Mahtari, 2022).

Students' mathematical disposition, the results of this study indicate that the average posttest of students' mathematical disposition was more than 83.99, the percentage of classical completion of the posttest of mathematical disposition was 88.2% (> 85%), and there was an increase for each indicator of mathematical disposition although not significant. The application of ethnomathematics in mathematics learning classes can improve students' mathematical disposition (Ulya & Rahayu, 2021). These results also prove the research of Viro et al. (2020) that PjBL can encourage students' mathematical disposition. The result of this study shows that the collaboration between the Project-Based Learning method and the ethnomathematics of the Walewangko house as a basis for learning is also effective for students' mathematical disposition. The process of building concepts, working on miniature projects directly, and problem-solving activities at the Walewangko house stimulate an increase in their disposition towards mathematics. Thus, their interest and curiosity in solving mathematical problems will be more stimulated; they can better understand and appreciate the important role of mathematics in their environment.

The findings of this study provide conceptual implications, namely that mathematics learning implemented by integrating ethnomathematics as a basis for project-based learning methods can be applied to improve students' creative thinking skills and mathematical dispositions. This also strengthens ethnomathematics as one of the contextual learning innovations that encourage students' mathematical development through a mathematization process based on the cultural context that exists and is close to them. Ethnomathematics also encourages students' positive attitudes towards mathematics. This study also further strengthens the theory that student-centered learning and the principle of "learning by doing" through the PjBL method develop students' self-confidence, interest, and collaboration with fellow students, as well as students' understanding of mathematics through real experiences and direct student involvement. In practice implications, the results of this study further strengthen the results of other studies related to the effectiveness of ethnomathematics-based learning even though the cultural contexts used are diverse. This study also provides guidelines for teachers to design cultural-based projects that are appropriate to the student's environment that can foster students' positive attitudes toward mathematics and encourage creative problem-solving skills.

Jurnal Kependidikan:
Jurnal Hasil Penelitian dan Kajian Kepustakaan di Bidang Pendidikan, Pengajaran dan Pembelajaran
https://e-journal.undikma.ac.id/index.php/jurnalkependidikan/index

Vol. 10, No. 4 : December 2024
E-ISSN: 2442-7667
pp. 1584-1595
Email: jklppm@undikma.ac.id

Conclusion

Based on the research results, it can be concluded that the Project-Based Learning method based on the ethnomathematics of Walewangko House is effective in improving students' creative thinking skills and mathematical disposition. In addition, this method is also effective in the achievement of students' creative thinking skills towards KKM and effective in students' mathematical disposition. Project-Based Learning based on the ethnomathematics of Walewangko House can be applied to train students in creative thinking and improve their mathematical disposition. This application also needs to pay attention to the selection of projects that allow for student learning experiences according to the learning objectives to be achieved, the time allocation available, and the availability of supporting tools and materials. Integration of ethnomathematics as a basis for learning, in addition to acting as a contextual learning innovation, teachers are also expected to introduce and instill in students cultural values related to the ethnomathematics used.

Recommendation

This experimental study presents the results of the application of Project-based learning based on ethnomathematics at Walewangko House to students' creative thinking skills and mathematical disposition empirically through quantitative analysis. Further research can be conducted to analyze more qualitatively about how students' creative thinking skills and mathematical dispositions are after receiving this learning. Other research can also be conducted to investigate whether these two research variables influence each other in the application of this learning method. For teachers, the project-based learning method should be one of the methods that is often applied in mathematics learning. In implementing this project-based learning, teachers need to choose the type of project that allows students to gain learning experiences that are in accordance with learning objectives, but also in accordance with the allocation of time and efficiency in providing tools and materials. Teachers can integrate ethnomathematics in learning as a contextual learning innovation, while also introducing and instilling cultural values related to the ethnomathematics used in students. Teachers can examine the cultural context in the surrounding area that is relevant to the content of school mathematics. In addition, mathematics curriculum developers are also expected to further develop ethnomathematics in mathematics learning, such as studies of cultural contexts that are relevant to school mathematics and integrating them into school textbooks.

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