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Integrating Batik Geblek Renteng Ethnomathematics into Mathematics Learning to Enhance Students' Numerical Literacy and Geometric Understanding: A Community Engagement Program

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Abstract. *This quantitative study employed a Community-Based Participatory Action Research (CBPAR) framework to implement ethnomathematics-based Problem-Based Learning (PBL) using the Batik Geblek Renteng motif as a contextual resource for primary mathematics learning. The program aimed to improve students' numeracy and geometric understanding while strengthening teachers' capacity to develop culturally contextualized mathematics learning materials. The program involved six teachers and 27 Phase C students at SD Sanjaya Tritis, Pakem, Sleman, Special Region of Yogyakarta. Data were collected through classroom observations, pre-tests and post-tests, and response questionnaires. The results showed that teacher adherence to all PBL instructional stages reached 100%, while student engagement consistently met the 80% benchmark. Students' mean scores increased from 16.30 in the pre-test to 46.56 in the post-test, with a statistically significant difference ($t = -6.22$, $p < 0.001$) and an overall N-Gain of 0.35, categorized as medium. Teachers' mean scores increased from 58.33 to 73.33, with a significant difference ($t = -4.11$, $p < 0.05$) and an N-Gain of 0.37. Student and teacher responses reached 82.45% and 87.08%, respectively. These findings indicate that integrating Batik Geblek Renteng into PBL provides a meaningful cultural context for connecting geometric concepts with students' experiences and supports teachers' culturally responsive instructional practices.*

Keywords: *ethnomathematics, numeracy, Problem-Based Learning*

INTRODUCTION

The development of mathematical proficiency in primary education depends substantially on students' ability to move from concrete experiences toward increasingly abstract mathematical reasoning. Geometry is among the areas that can be challenging for primary students because it requires them to visualize shapes, recognize their properties, and establish relationships between mathematical representations and objects in their surroundings (Clements & Battista, 1992; Fitriani & Rohaeti, 2020; Waluyo & Nuraini, 2021). Similarly, numeracy requires students to apply mathematical knowledge and reasoning in meaningful real-world

contexts (Geiger et al., 2015; Niss, 2003; OECD, 2019). However, students may experience difficulties when mathematics is presented primarily through abstract or procedural forms without sufficient connections to their everyday experiences (Gravemeijer, 1994; Treffers, 1987).

These challenges were identified at SD Sanjaya Tritis through a preliminary needs assessment involving teachers from Phases A, B, and C. Teachers reported that students experienced difficulties in solving contextual problems, distinguishing the properties of two-dimensional (2D) shapes, and relating abstract geometric concepts to objects in their immediate environment. The percentage of students meeting the expected mathematics mastery criteria was approximately 35%–40%, indicating the need for learning activities that provide stronger connections between mathematical concepts and students' experiences. Although teachers had attempted to utilize students' surroundings and digital media as learning resources, Phase C teachers reported that developing contextual problems consistently for daily instruction required substantial preparation time.

Ethnomathematics provides a potential approach to addressing these challenges by connecting mathematical ideas with cultural practices, artifacts, and traditions (Barton, 1996; Rosa & Orey, 2011; Ubiratan D'Ambrosio, 2001). Familiar cultural contexts can provide meaningful points of reference that help students connect mathematical reasoning with their lived experiences and recognize mathematics within their surrounding environment. In this context, Batik Geblek Renteng, a traditional motif associated with the Kulon Progo and Sleman regions of the Special Region of Yogyakarta, provides a relevant context for exploring geometric concepts. Its interconnected circular and elliptical patterns, triangular elements, and rectangular borders offer opportunities to identify and investigate geometric forms through a culturally familiar artifact.

Previous studies have demonstrated the potential of batik and other cultural artifacts as contexts for ethnomathematics learning (Ayuningtyas & Setiana, 2019; Febrina et al., 2022; Manoy & Purbaningrum, 2021; Prahmana & D'Ambrosio, 2020). However, there remains a need for structured intervention programs that transform the geometric features of Batik Geblek Renteng into classroom-ready

instructional materials, particularly materials that can be implemented through an appropriate pedagogical framework. Problem-Based Learning (PBL) provides a suitable framework because it engages students in understanding problems, organizing information, investigating possible solutions, presenting findings, and reflecting on the problem-solving process (Hmelo-Silver, 2004; Savery, 2006). When combined with culturally meaningful contexts, PBL can provide opportunities for students to apply mathematical concepts to problems connected with familiar situations while actively developing their reasoning and problem-solving processes.

Successful implementation of ethnomathematics also requires attention to teachers' pedagogical capacity. Cultural artifacts may function merely as illustrations if teachers are not supported in identifying their mathematical potential and transforming them into meaningful learning activities. Collaborative professional development can therefore help teachers move beyond being recipients of instructional materials toward becoming active participants in adapting and developing materials according to their classroom contexts (Garet et al., 2001). Such involvement is particularly important when teachers are expected to integrate local cultural resources with curriculum objectives, mathematical concepts, and contextual problem-solving activities.

Based on these considerations, this article reports the implementation and outcomes of a community engagement program that integrated Batik Geblek Renteng ethnomathematics into primary mathematics learning at SD Sanjaya Tritis. The program was designed to connect abstract mathematical concepts with students' cultural and everyday experiences through culturally contextualized PBL. The program pursued two main objectives: first, to support students' understanding of 2D geometry and numeracy through contextualized mathematics learning; and second, to strengthen teachers' capacity to design and implement ethnomathematics-based instructional materials. In addition, students' and teachers' responses to the developed instructional materials and learning activities were examined to assess their practicality, relevance, and potential for continued use in primary mathematics classrooms.

RESEARCH METHODS

Research Design And Participants

This study employed a quantitative approach within a Community-Based Participatory Action Research (CBPAR) framework. The collaborative framework was designed to address two related objectives: strengthening teachers' pedagogical capacity as co-designers of instructional materials and improving students' mathematics learning through classroom implementation. The program was conducted at SD Sanjaya Tritis, Pakem, Sleman, Special Region of Yogyakarta. Six primary school teachers from Phases A, B, and C participated in the community engagement activities. The classroom implementation and student data collection focused on 27 Phase C students, consisting of 14 students from Grade V and 13 students from Grade VI.

Program Implementation

The intervention was implemented through four interconnected stages: preparation and needs assessment, instructional material and instrument development, classroom implementation, and evaluation. These stages were designed as a continuous process in which the findings from the initial assessment informed the development of the instructional materials, while the results of classroom implementation were subsequently used to evaluate the effectiveness, practicality, and relevance of the program. The implementation also involved collaboration between the program team and participating teachers to ensure that the learning materials were appropriate for the students' characteristics and could be integrated into the existing mathematics learning process.

The first stage was preparation and needs assessment. At this stage, diagnostic questionnaires were administered to identify instructional challenges experienced by teachers and learning difficulties encountered by students. Particular attention was given to students' difficulties in visualizing geometric concepts, understanding the properties and measurements of two-dimensional shapes, and connecting mathematical ideas with concrete objects and situations in their surroundings. The

assessment also provided an initial basis for identifying the need for contextual learning resources that could make geometric concepts more accessible and meaningful to primary school students. In addition, the preparation stage involved coordination with participating teachers concerning the learning objectives, classroom conditions, instructional schedule, and implementation procedures. This process ensured that the subsequent intervention was aligned with the needs and context of the partner school.

The second stage was instructional material and instrument development. Based on the needs identified during the preparation stage, the program team and participating teachers collaboratively developed an ethnomathematics-based mathematics module and four Student Worksheets (Lembar Kerja Peserta Didik/LKPD). The Batik Geblek Renteng motif was selected as the main cultural context because its visual patterns provided opportunities to introduce and explore geometric ideas through a familiar local cultural artifact. The instructional materials were designed to facilitate students' exploration of two-dimensional geometric shapes, their elements and properties, perimeter, area, and contextual problems involving geometric designs. The materials were organized according to the Problem-Based Learning (PBL) framework so that students were not only exposed to mathematical concepts but were also encouraged to investigate problems, discuss mathematical relationships, develop solutions, and communicate their reasoning. During this stage, the participating teachers were also involved in reviewing and adapting the materials to ensure their suitability for classroom use. In addition to the learning materials, observation instruments, pre-test and post-test instruments, and response questionnaires were prepared to document the implementation process and assess changes in students' and teachers' learning outcomes and perceptions.

The third stage was classroom implementation. The developed instructional materials were implemented through four structured meetings using the PBL framework. Each meeting was organized around contextual mathematical problems derived from the Batik Geblek Renteng motif and was designed to progressively develop students' geometric understanding. In Meeting 1, students explored geometric shapes and identified geometric elements represented in the batik motif.

The activity introduced students to the relationship between mathematical shapes and patterns found in a familiar cultural object. In Meeting 2, students examined the properties of two-dimensional shapes and applied measurement concepts to determine their perimeter. Students were encouraged to observe the characteristics of the shapes, discuss their properties, and use appropriate mathematical procedures to solve the problems presented in the LKPD. In Meeting 3, the learning activities focused on calculating the area of two-dimensional shapes. Students worked with contextual problems that required them to identify relevant information, select appropriate formulas, perform calculations, and interpret their results. In Meeting 4, students were presented with contextual problems involving composite geometric designs. This meeting provided an opportunity for students to integrate the geometric concepts developed in the previous meetings and apply them to more complex situations. Across the four meetings, the PBL stages involved orienting students to the problem, organizing students for learning, guiding individual and group investigation, developing and presenting solutions, and analyzing and evaluating the problem-solving process. These activities were intended to promote active participation while strengthening students' ability to connect mathematical concepts with cultural and everyday contexts.

The fourth stage was evaluation. Evaluation was conducted to examine the implementation of the learning process, changes in students' mathematical performance, teachers' pedagogical capacity, and participants' responses to the developed instructional materials. Classroom observations were used to document teacher adherence to the planned PBL stages and student engagement during the learning activities. Pre-tests and post-tests were administered to examine changes in students' mathematical performance following the intervention, while similar assessments were used to examine changes in teachers' pedagogical capacity related to the implementation of the program. Response questionnaires were also administered to obtain participants' perceptions of the instructional materials, including their practicality, relevance, cultural context, and contribution to the learning process. The evaluation results were subsequently used to assess the extent to which the program achieved its intended objectives and to identify aspects that

could be considered for further implementation and improvement. Through this four-stage process, the intervention sought to establish a coherent connection between local cultural knowledge, mathematical concepts, problem-based learning activities, and teacher professional development.

Data Collection And Analysis

Data were collected using three main instruments: classroom observation sheets, written tests, and questionnaires. The use of multiple instruments was intended to obtain complementary information concerning the implementation of the intervention, changes in students' and teachers' learning outcomes, and participants' perceptions of the instructional materials and learning activities. The combination of observational, performance-based, and response data also enabled the program team to examine the intervention from both process and outcome perspectives.

Classroom observations were conducted during the implementation of the four instructional meetings using structured observation rubrics. The observation sheets were designed to document the extent to which the planned Problem-Based Learning (PBL) stages were implemented in the classroom and to record students' participation throughout the learning process. The observed instructional components included the introduction and apperception activities, orientation of students to the problem, organization of students for learning, guidance during individual and group investigation, development and presentation of solutions, analysis and evaluation of the problem-solving process, and closing and reflection activities. Teacher implementation was assessed by comparing the observed classroom practices with the predetermined instructional components in the PBL framework. Student engagement was assessed based on their participation in the learning activities and their involvement in the problem-solving process. The observation results were subsequently summarized descriptively by calculating the percentage of successfully implemented components. Student engagement was also compared with the predetermined benchmark of 80% to determine whether the level of participation met the expected criterion.

Student and teacher learning outcomes were measured through written pre-tests and post-tests administered before and after the intervention. The student assessment was designed to measure mathematical understanding and numeracy related to two-dimensional geometry. The assessment covered students' ability to identify geometric shapes and their properties, recognize and determine geometric elements, calculate the perimeter and area of two-dimensional shapes, and apply these concepts to contextual numeracy problems. The contextual component was designed to assess students' ability to interpret information from a problem situation, identify relevant mathematical concepts, select appropriate procedures, and obtain solutions based on the given context. The pre-test was administered before the classroom intervention to establish students' initial performance, whereas the post-test was administered after the four learning meetings to identify changes following the implementation of the ethnomathematics-based PBL activities.

The teacher assessment was designed to examine teachers' practical understanding and pedagogical capacity in applying ethnomathematics to mathematics learning. The assessment focused on three main areas: practical understanding of ethnomathematics, strategies for integrating ethnomathematics into mathematics instruction, and the ability to develop open-ended contextual problems. The pre-test and post-test therefore served not only to identify changes in teachers' conceptual understanding but also to examine the extent to which participation in the program supported their capacity to translate ethnomathematical ideas into classroom-oriented instructional practices. Teacher assessment data were collected across the participating teachers and subsequently summarized to describe changes at the individual phase level and at the overall program level.

In addition to the tests and classroom observations, questionnaires were administered to both teachers and students after the implementation of the instructional activities. The questionnaires used a four-point Likert scale to capture participants' responses without providing a neutral midpoint. The student questionnaire examined their perceptions of the learning experience and the developed instructional materials, particularly in relation to the practicality of the

module and Student Worksheets (LKPD), the relevance and attractiveness of the Batik Geblek Renteng cultural context, and the extent to which the learning activities supported their engagement with mathematics. The teacher questionnaire focused on the feasibility and practicality of the instructional materials, the integration of ethnomathematical content, the design and usability of the materials, and the perceived impact of the program on engagement and the learning process. These questionnaire data provided additional information for interpreting the quantitative learning outcomes and classroom implementation findings.

The data analysis consisted of descriptive and inferential procedures. Observation data were analyzed descriptively by calculating the percentage of instructional components that were successfully implemented. The percentage was determined by comparing the number of components successfully implemented with the total number of planned components. Student engagement percentages were interpreted in relation to the predetermined 80% benchmark. This analysis was used to determine whether the implementation of the PBL learning process and student participation had reached the expected level during the intervention.

For the written test data, pre-test and post-test scores were first summarized using descriptive statistics, including mean scores and standard deviations where applicable. Differences between pre-test and post-test scores were then examined using paired-samples t-tests because the measurements were obtained from the same participants before and after the intervention. The analysis was conducted separately for student and teacher outcomes to determine whether the observed changes in scores were statistically significant. Statistical significance was interpreted using the reported probability values, with the student outcome evaluated at $p < 0.001$ and the teacher outcome at $p < 0.05$.

Normalized gain (N-Gain) scores were also calculated to describe the magnitude of improvement in participants' performance relative to the possible improvement between the pre-test and the maximum attainable score. The N-Gain analysis was used to complement the paired-samples t-test by providing information about the practical magnitude of score improvement rather than focusing only on statistical significance. For students, N-Gain scores were

examined both at the grade level and for the overall group, allowing comparison between Grade V and Grade VI performance. For teachers, N-Gain scores were summarized according to the participating phases and for the overall teacher group.

Questionnaire responses were converted into percentage scores by comparing the obtained score with the maximum possible score and expressing the result as a percentage. The resulting percentages were used descriptively to summarize participants' perceptions of the instructional materials and learning activities. For students, the analysis included overall responses as well as aspects related to the practicality of the module and LKPD and the cultural context or ethnomathematical integration. For teachers, the analysis considered content feasibility, ethnomathematics integration, design practicality, and the perceived impact of the program on engagement and the learning process. These percentage scores were interpreted together with the classroom observation and learning outcome data to provide a more comprehensive description of the implementation and outcomes of the community engagement program.

Overall, the analysis was designed to integrate evidence from implementation, learning outcomes, and participant responses. Observation data provided information about the fidelity of the instructional process, pre-test and post-test data described changes in mathematical and pedagogical performance, N-Gain scores indicated the magnitude of improvement, and questionnaire data captured participants' perceptions of the relevance and practicality of the intervention. The integration of these data sources enabled the study to assess not only whether changes occurred following the intervention but also how the ethnomathematics-based PBL approach was implemented and perceived within the primary school context.

RESULTS AND DISCUSSION

Baseline Conditions And Implementation Fidelity

The preliminary needs assessment provided important information regarding the instructional conditions at SD Sanjaya Tritis. Teachers across the participating phases consistently identified the transition from concrete objects to abstract

mathematical properties as one of the main challenges in teaching 2D geometry. Teachers in Phases B and C particularly reported difficulties in helping students distinguish geometric concepts using real objects and visualize shapes when they underwent transformations.

Although teachers had previously attempted to incorporate digital media and objects from students' surroundings, the absence of standardized and culturally relevant instructional materials made consistent implementation difficult. Nevertheless, teachers demonstrated strong interest in integrating local cultural contexts into mathematics instruction, providing a favorable foundation for the intervention. The core intervention was subsequently implemented through four classroom meetings using the Batik Geblek Renteng-based instructional materials. Classroom observations indicated that the developed materials could be implemented consistently within the PBL framework.

Table 1. Summary of Classroom Observation Results for Phase C Teachers

Instructional Phase (PBL Syntax)	Teacher Compliance	Student Engagement (>80%)
Introduction and Apperception	100%	100%
Step 1: Orienting students to the problem	100%	100%
Step 2: Organizing students for study	100%	100%
Step 3: Guiding independent/group investigation	100%	100%
Step 4: Developing and presenting results	100%	100%
Step 5: Analyzing and evaluating problem-solving	100%	100%
Closing and Reflection	100%	100%

Across the four instructional meetings, teacher adherence to the planned Problem-Based Learning (PBL) stages reached 100%, while student engagement consistently met and exceeded the predetermined 80% benchmark at every observed instructional stage (Table 1). These findings indicate that the learning activities could be implemented according to the planned instructional sequence and that students were actively involved throughout the learning process. The consistent implementation was supported by the use of structured learning materials, contextual problems, and Student Worksheets (LKPD) that guided students through the different stages of problem solving. Rather than positioning

the teacher as the sole source of mathematical information, the learning process emphasized students' active participation in observing, discussing, investigating, and communicating mathematical ideas.

During the first meeting, physical Batik Geblek Renteng cloth was used as an introductory learning resource. The use of an authentic cultural artifact provided students with a concrete visual starting point for identifying geometric shapes and elements embedded within the batik motif. Students were encouraged to observe the patterns directly, identify recognizable geometric forms, and discuss the mathematical characteristics that could be found in the design. This initial activity served to bridge students' existing familiarity with the cultural artifact and the formal mathematical concepts introduced during the lesson. Consequently, geometric ideas were not introduced solely through textbook illustrations or abstract symbolic representations, but through an object that was visually and culturally meaningful to the students.

The subsequent meetings gradually developed the mathematical concepts identified during the initial exploration. In the second meeting, which focused on the properties of two-dimensional shapes and perimeter, students worked collaboratively to examine geometric features represented in the batik design and to determine relevant measurements. Teachers facilitated group investigations by providing guiding questions and supporting students as they connected their observations with the mathematical properties and procedures required to calculate perimeter. Students were therefore encouraged to move from visual recognition toward mathematical analysis. The activity also provided opportunities for students to compare geometric forms, discuss their characteristics, and justify the procedures used to obtain their solutions.

The third meeting focused on the concept of area. Building on the geometric exploration conducted in the previous meetings, students investigated the dimensions of relevant two-dimensional shapes and applied appropriate mathematical formulas to determine their areas. The teacher's role was primarily to facilitate the investigation and guide students when they encountered difficulties in interpreting the problems or selecting appropriate procedures. Through the LKPD,

students were directed to identify the information provided, determine the mathematical concept required, perform calculations, and communicate their findings. This sequence allowed students to experience a gradual transition from concrete observation of a cultural object to the use of formal mathematical procedures.

The fourth meeting involved contextual problems related to composite geometric designs. At this stage, students were expected to integrate the geometric knowledge developed during the previous meetings and apply it to more complex contextual situations. The problems required students to interpret the design, identify the constituent geometric shapes, determine the relevant measurements, and combine mathematical procedures to obtain solutions. Group discussion and presentation activities provided opportunities for students to compare different solution strategies and explain their mathematical reasoning. The activity therefore functioned as an integrative stage in which the concepts of geometric shapes, properties, perimeter, and area were applied within a contextual problem-solving situation.

Across the four meetings, the implementation of PBL provided a consistent structure for connecting the cultural context with mathematical investigation. The sequence from observing the Batik Geblek Renteng motif, identifying geometric elements, investigating their properties and measurements, and solving contextual problems created a progression from concrete experience toward formal mathematical understanding. The 100% teacher adherence indicates that all planned instructional components were implemented as intended, while the consistently high level of student engagement suggests that students participated actively in the learning process. These observations are important because the integration of ethnomathematics does not depend solely on the presence of a cultural object in the classroom; its educational value emerges when the cultural context is deliberately connected to mathematical investigation and problem solving.

The use of Batik Geblek Renteng as a contextual anchor also provided a culturally relevant entry point for discussing mathematical concepts that may otherwise be presented in relatively abstract forms. Students were able to encounter

geometric ideas through patterns and structures that originated from their local cultural environment and subsequently connect those observations with formal mathematical terminology, properties, measurements, and calculations. In this sense, the batik motif functioned not merely as an illustration or decorative element, but as a learning context through which mathematical questions could be formulated and investigated. Such an approach is consistent with the broader rationale of contextual and problem-based mathematics learning, in which meaningful situations can encourage students to participate more actively in mathematical reasoning and make connections between mathematical concepts and their experiences (Mashuri et al., 2019).

The implementation also illustrates the potential of ethnomathematics to strengthen the relevance of mathematics learning without reducing the learning process to cultural recognition alone. The cultural artifact became a starting point for mathematical inquiry, while the PBL structure provided the pedagogical mechanism through which students investigated and solved the resulting mathematical problems. Thus, the combination of Batik Geblek Renteng and PBL established a learning environment in which cultural knowledge and formal mathematical knowledge could be connected systematically. This finding supports the view that culturally contextualized mathematics learning can provide meaningful opportunities for students to interpret mathematical concepts through familiar contexts while simultaneously engaging in structured mathematical problem solving.

Students' Numeracy And Geometric Understanding

Before the intervention, students demonstrated relatively low performance in the assessed areas of numeracy and two-dimensional geometry. The pre-test administered to the 27 Phase C students produced an overall mean score of 16.30 out of 100 (SD = 10.20), indicating that students had limited initial mastery of the assessed mathematical concepts. Following the four-meeting intervention, which integrated Batik Geblek Renteng ethnomathematics into Problem-Based Learning activities, the mean post-test score increased to 46.56 (SD = 23.51). This

improvement indicates a positive change in students' performance after participating in the contextualized learning activities. However, the relatively large variation in post-test scores suggests differences in the extent to which students benefited from the intervention. The detailed comparison of students' performance by grade level, together with the corresponding N-Gain results, is presented in Table 2.

Table 2. Students' Pre-test and Post-test Performance in Geometry and Numeracy

Group	N	Mean Pre-test	Mean Post-test	SD Post-test	N-Gain
Grade V	14	17.00	32.86	21.65	0.18
Grade VI	13	15.54	61.31	14.28	0.54
Overall	27	16.30	46.56	23.51	0.35

A paired-samples t-test indicated a statistically significant difference between the pre-test and post-test scores ($t = -6.22$, $p < 0.001$). This result indicates that students' performance after the intervention was significantly higher than their performance before the intervention (Table 2). The finding provides quantitative evidence that the learning activities were associated with a substantial improvement in students' assessed numeracy and geometric understanding following the four-meeting intervention. The statistical significance also strengthens the interpretation that the observed increase in students' scores was not merely reflected in descriptive changes between the two measurement occasions. However, statistical significance alone does not describe the magnitude of the improvement; therefore, the N-Gain analysis was used to provide additional information about the level of students' improvement.

The overall N-Gain score was 0.35, which falls within the medium category according to the classification proposed by Hake (1999). This result suggests that the intervention produced a moderate level of improvement in students' performance when the possible score improvement is taken into consideration. The improvement differed between the two participating grades. Grade VI students demonstrated a higher mean post-test score of 61.31 and an N-Gain of 0.54, whereas Grade V students obtained a mean post-test score of 32.86 and an N-Gain of 0.18.

The difference indicates that the intervention did not produce an identical magnitude of improvement across the two grade levels. This variation may be associated with differences in students' developmental readiness and their capacity to process more complex geometric contexts. In particular, composite geometric problems require students to coordinate several pieces of information and apply more than one mathematical relationship. Students who have greater prior familiarity with geometric concepts may therefore have more resources available to interpret contextual information and select appropriate solution strategies.

Despite the difference in magnitude, classroom observations indicated a common qualitative change in students' engagement with mathematical problems. When students were presented with contextual open-ended tasks, such as calculating material costs or dye volumes associated with particular batik designs, they were encouraged to interpret numerical information in relation to tangible situations. Such activities provided opportunities for students to move beyond direct application of formulas and consider how mathematical information could be interpreted within a particular context. The cultural context therefore served not merely as an illustration but as a starting point for mathematical reasoning. By beginning with a recognizable cultural artifact, students could identify mathematical elements before connecting their observations with formal concepts and procedures. These findings are consistent with the underlying principles of ethnomathematics, which position mathematical ideas within culturally meaningful contexts (Barton, 1996; Rosa & Orey, 2011; Ubiratan D'Ambrosio, 2001). The use of batik patterns provided students with visual and contextual references that could help bridge concrete experiences and formal geometric representations. This connection is particularly relevant in primary mathematics learning, where students may benefit from opportunities to relate abstract concepts to objects and situations that are familiar within their environment. Previous studies have similarly demonstrated the potential of batik contexts to support mathematical literacy and geometry learning (Manoy & Purbaningrum, 2021; Prahmana & D'Ambrosio, 2020).

The student questionnaire results further supported the positive classroom experience. The overall student response reached 82.45%, indicating that the majority of students responded positively to the learning activities and instructional materials. The aspect of Module and LKPD Practicality obtained a score of 87.78%, indicating that students generally perceived the materials as accessible and well organized. This relatively high response suggests that the instructional materials were sufficiently supportive for students as they worked through the contextual mathematical tasks. The Cultural Context (Ethnomathematics) aspect received a score of 83.15%, further indicating positive student perceptions of the incorporation of Batik Geblek Renteng into the learning process. These responses suggest that the Geblek Renteng context helped students recognize geometric shapes and relate school mathematics to situations that were familiar to them. The positive responses also complement the classroom observation findings by indicating that students not only participated actively during the learning process but also perceived the instructional materials and cultural context favorably. The findings are also consistent with research emphasizing the importance of contextual and meaningful learning experiences in mathematics. When mathematical tasks are connected with students' experiences and surroundings, students may have greater opportunities to interpret mathematical concepts as useful tools rather than as isolated procedures (Toheri et al., 2020). In this respect, the integration of Batik Geblek Renteng provided a meaningful contextual layer that complemented the problem-based structure of the learning activities.

Changes In Teachers' Pedagogical Capacity

An important component of the program was strengthening teachers' capacity to move from being users of instructional materials to becoming active participants in their design and implementation. The pre-test and post-test administered to the six participating teachers assessed their capacity to design ethnomathematics-based open-ended questions and integrate cultural contexts into mathematics instruction. Through this process, teachers were encouraged to identify mathematical concepts embedded in local cultural artifacts and translate them into meaningful learning

activities. The program also provided opportunities for teachers to consider how contextual problems could be structured to stimulate students' mathematical reasoning rather than merely require routine calculations. In this way, teacher development was positioned as an integral part of the intervention, supporting the sustainability of ethnomathematics-based mathematics learning beyond the implementation of the program.

Table 3. Teachers' Pedagogical Assessment and Survey Responses

Metric	Pre-test Mean	Post-test Mean	N-Gain	Survey Aspect	Score (%)
Phase A (n = 2)	60.00	65.00	0.13	A. Content Feasibility	85.00%
Phase B (n = 2)	55.00	70.00	0.33	B. Ethnomathematics Integration	88.33%
Phase C (n = 2)	60.00	85.00	0.63	C. Design Practicality	83.33%
Overall (n = 6)	58.33	73.33	0.37	D. Engagement Impact	91.67%

The overall teacher pre-test mean was 58.33, increasing to 73.33 after the collaborative mentoring process (Table 3). A paired-samples t-test indicated a statistically significant improvement in teachers' pedagogical capacity ($t = -4.11$, $p < 0.05$). This improvement suggests that the intervention contributed to strengthening teachers' capacity to understand and apply ethnomathematical principles in mathematics instruction. More importantly, the increase was accompanied by teachers' direct involvement in developing instructional materials and implementing them in the classroom, allowing pedagogical knowledge to be connected with practical teaching situations. The highest N-Gain was observed among the Phase C teachers, with a score of 0.63, categorized as medium. The relatively higher gain among Phase C teachers may be associated with their more direct involvement in classroom implementation, which provided opportunities to observe students' responses and reflect on the use of contextual problems in actual instruction. Such experiences may have helped teachers move beyond conceptual

understanding toward a more practical understanding of how local cultural contexts can be transformed into mathematical learning activities.

The teacher questionnaire produced an overall positive response of 87.08%, providing additional support for the quantitative findings. The Engagement Team Impact aspect received the highest score of 91.67%, indicating that teachers perceived the support provided through the program as relevant to their classroom needs. This result suggests that the collaborative nature of the intervention was an important component of the program because teachers were not positioned merely as recipients of training, but were involved in the development and implementation of the instructional approach. The Ethnomathematics Integration aspect obtained a score of 88.33%, suggesting that teachers generally viewed the cultural components as supportive of, rather than distracting from, the mathematical content. This perception is important because the integration of cultural contexts should maintain a clear connection with mathematical learning objectives rather than treating culture as an additional or decorative component of instruction.

The use of structured LKPD templates and contextual problem formats also provided teachers with a practical framework for developing mathematics activities based on local cultural contexts. Such resources can potentially reduce the preparation burden associated with designing contextual problems because teachers are provided with an instructional structure that can be adapted to their classroom needs. This aspect is particularly relevant because the initial needs assessment identified teachers' limited preparation time as one of the barriers to consistently incorporating contextual problems into daily mathematics instruction. The availability of structured materials may therefore help teachers focus their preparation on adapting mathematical content and cultural contexts rather than developing the entire instructional framework from the beginning. Nevertheless, the potential for continued use of these materials would depend on teachers' ability to adapt them to different mathematical topics and classroom conditions.

The findings reinforce the importance of professional development that involves teachers actively in the design and implementation of instructional innovations. Professional development is more likely to contribute to changes in

classroom practice when teachers have opportunities to engage with content, pedagogy, and classroom applications rather than simply receive information (Garet et al., 2001). In the present program, collaborative material development, mentoring, and direct classroom implementation created opportunities for teachers to experience the relationship between ethnomathematical concepts, instructional design, and student learning activities. This form of professional engagement is particularly relevant for ethnomathematics because teachers need not only conceptual knowledge about cultural mathematics but also the pedagogical ability to identify appropriate cultural contexts and transform them into meaningful mathematical tasks. The positive changes in teacher assessment scores and questionnaire responses therefore suggest that professional learning based on active participation may be a promising approach for supporting the integration of local culture into mathematics instruction.

Overall, the findings indicate that integrating Batik Geblek Renteng ethnomathematics with PBL has the potential to serve a dual function: providing students with a meaningful cultural context for learning mathematics while supporting teachers in developing culturally responsive instructional practices. The student findings demonstrate the potential of the approach at the classroom level, whereas the teacher findings indicate that the intervention may simultaneously contribute to teachers' pedagogical development. This combination is important because the sustainability of contextualized mathematics learning depends not only on the availability of culturally relevant materials but also on teachers' capacity to use and adapt such materials appropriately. However, these findings should be interpreted within the scope of the present program, which involved six teachers and 27 students and was implemented through four classroom meetings. The relatively small participant group and limited intervention period restrict the extent to which the findings can be generalized to other schools and educational contexts. Further studies involving larger and more diverse participant groups, longer implementation periods, and follow-up observations are needed to examine whether the observed improvements can be sustained and transferred to broader mathematics learning contexts.

CONCLUSION

The implementation of an ethnomathematics-based mathematics learning program using the Batik Geblek Renteng motif showed potential for supporting students' numeracy and geometric understanding while strengthening teachers' capacity to develop culturally contextualized instructional materials. Classroom observations indicated 100% adherence to the PBL instructional stages, with student engagement consistently exceeding the predetermined 80% benchmark. Students' mean assessment score increased from 16.30 before the intervention to 46.56 after the intervention. The difference was statistically significant ($p < 0.001$), with an overall N-Gain of 0.35, categorized as medium. Differences were also observed between Grade V and Grade VI, with Grade VI demonstrating a greater increase in performance.

The program also contributed to improvements in teachers' pedagogical capacity. The teachers' mean score increased from 58.33 to 73.33, with the improvement being statistically significant ($p < 0.05$) and an overall N-Gain of 0.37. Positive responses from students and teachers toward the instructional materials reached 82.45% and 87.08%, respectively.

Taken together, these findings suggest that Batik Geblek Renteng can serve as a meaningful cultural context for connecting abstract geometric concepts with students' concrete experiences. The combination of ethnomathematics and PBL also offers teachers a structured approach for designing contextual mathematics learning activities. Nevertheless, because the program involved a limited number of participants and a relatively short implementation period, further studies involving larger groups, longer implementation periods, and varied school contexts are needed to examine the sustainability and broader applicability of the approach.

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