

Dance and Mathematics: Elementary Spatial Mathematics Problems Using the Context of the *Kembang Kahyangan* Dance

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ABSTRACT

The geometry concepts at the primary school level are often perceived as abstract and insufficiently connected to real-life contexts, which remains a concern in mathematics education. This study aims to develop spatial mathematics problems based on the cultural context of the *Kembang Kahyangan* dance from Bojonegoro as an alternative culture-based learning resource. The study employed research and development (R&D) design using a modified ADDIE model limited to the development stage. The research subjects consisted of two expert lecturers who served as validators. The instrument used was a problem validation sheet with a four-point Likert scale, and the data were analyzed using descriptive quantitative and qualitative techniques. The developed problems integrate plane geometric concepts aligned with the outcomes of the Merdeka curriculum and are structured according to the Van Hiele levels of geometric thinking (visualization, analysis, and informal deduction). The validation results showed percentages of 95.83% and 91.66%, both categorized as “very valid,” indicating that the product is suitable for use. The findings suggest that local cultural contexts can be systematically integrated into problem design aligned with spatial ability indicators. This study contributes to the development of ethnomathematics-based problem design in primary school geometry learning. Further research is recommended to examine the practicality and effectiveness of the developed product through implementation with students.

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Mathematics is a compulsory subject at every level of education in Indonesia. It plays an important role in human life as it helps develop logical, critical, and systematic reasoning skills (Catarino et al., 2019; Putri et al., 2024). One of the essential branches of mathematics is geometry, which studies shapes, space, patterns, and the relationships among objects in our surroundings (Ramadhini & Mahdi, 2020; Herlina et al., 2023). Fundamentally, the structure of mathematics is rooted in geometric aspects that rely on spatial reasoning (Shmigirilova et al., 2025). The National Council of Teachers of Mathematics (2000) stated that the goal of learning geometry is to enhance individuals' ability to study shapes, analyze their characteristics, and improve spatial visualization. Spatial ability plays a crucial role in understanding geometric concepts, as it relates to how individuals visualize, interpret, and manipulate objects (Satriani et al., 2023; Tarng et al., 2024).

However, in practice, students often face difficulties in solving geometry problems, particularly those related to two-dimensional shapes. These difficulties are generally caused by low spatial ability, which makes geometric concepts seem abstract and difficult to understand (O'ljayevna & Shavkatovna, 2020; Usman et al., 2020). This condition indicates the importance of implementing contextual learning so that students can understand geometric concepts in a more concrete manner. One possible effort to achieve this is by presenting mathematics problems that are directly connected to real-life contexts and everyday activities.

Such problems are referred to as contextual problems, which link learning materials to real-life situations (Zaiturrahmah et al., 2024). One form of contextual problem is culture-based problems, as culture is inherent and closely related to students' daily lives. The use of culture in a broader sense is known as ethnomathematics, a field of study that explores the relationships among culture, history, society, and mathematics (Richardo et al., 2020; Fatkhurohman et al., 2021). Conceptually, ethnomathematics refers to mathematical practices that emerge within identifiable social groups, such as communities, workers, children, or professional groups (D'Ambrosio, 1985). This approach facilitates students' understanding of abstract geometric concepts (Fredy et al., 2020). Furthermore, it helps students learn mathematics in a more meaningful way while simultaneously serving as an effort to preserve local culture (Wulandari et al., 2024; Sangadah et al., 2025; Solihin et al., 2025).

As part of Indonesia, Bojonegoro possesses abundant local cultural heritage, one of which is the *Kembang Kahyangan* dance, a creative dance that depicts the charm of the *Kayangan Api* natural tourist attraction in Bojonegoro. According to Tupen et al. (2023), elements in dance art are closely related to mathematical concepts, particularly geometry. For example, floor patterns can be associated with plane figures, while hand movements may represent straight lines and symmetry. However, most ethnomathematics studies still focus on exploring mathematical concepts embedded in local culture, rather than developing problem designs that are systematically aligned with outcomes and the theoretical framework of Van Hiele's levels of geometric thinking.

Field findings, such as those identified at SDN Pacing 2 Sukosewu, indicate that mathematics instruction remains centered on textbook materials as the primary learning resource, with limited connection to real-life contexts in the surrounding environment. As a result, learning tends to feel abstract and less contextualized. Teachers also reported that several students experience difficulties in representing two-dimensional objects. In addition, most students are not familiar with the *Kembang Kahyangan* dance, one of Bojonegoro's local cultural heritages.

Therefore, the application of an ethnomathematics approach using the context of the *Kembang Kahyangan* dance is viewed as a potentially contextual design alternative to introduce local culture while supporting students in understanding geometric concepts in a more concrete and meaningful way. However, this study does not focus on measuring students' geometric and spatial abilities; rather, it emphasizes the development of problem design, thereby contributing at a conceptual and design level rather than evaluating instructional effectiveness.

Previous studies have shown that local culture plays an important role in developing students' spatial thinking skills. Various cultural contexts have been integrated into mathematics learning, such as traditional foods (Febriyanto et al., 2025; Perdani, 2020), traditional games (Fadhilah & Sholikin, 2025; Putri & Supriadi, 2024), and traditional tools (Hidayat & Linda, 2023; As'ari & Kusaeri, 2024). Although numerous studies have examined the use of local culture in mathematics education, no study has specifically developed spatial mathematics problems based on the *Kembang Kahyangan* dance that are systematically aligned with both the Van Hiele levels of geometric thinking and the outcomes of the Merdeka curriculum. Therefore, this study was conducted to address this gap. The identified research gap lies in the absence of a systematic integration of local cultural context, spatial mathematics problem design, and the Van Hiele theoretical framework within a single expert-validated development product.

Based on the above description, this study aims to produce spatial mathematics problems grounded in the context of the *Kembang Kahyangan* dance for primary school students. The novelty of this study lies in the integration of a regional dance context as the foundation for spatial mathematics problem design, systematically structured according to the Van Hiele levels of geometric thinking and aligned with the Merdeka curriculum. This study contributes to the development of ethnomathematics-based problem design in primary school geometry learning.

METHODS

The type of research employed in this study is research and development (R&D). This method was selected because it focuses on a systematic process for developing and producing a valid product (Hanafi, 2022). In the context of this study, the product developed consists of spatial mathematics problems based on the local cultural context of the *Kembang Kahyangan* dance, designed in alignment with spatial ability indicators grounded in the theoretical framework of the Van Hiele levels of geometric thinking at the primary school level.

The development model employed in this study was the ADDIE model, which consists of five main stages: analyze, design, development, implementation, and evaluation. However, this study was limited to the development stage; therefore, the implementation and field evaluation stages involving students were not conducted. This limitation was applied because the focus of the study was on product design and validation rather than on testing instructional effectiveness.

The analysis stage was conducted through a semi-structured interview with one classroom teacher to identify issues in geometry instruction and the need for problem development. The design stage involved formulating the problem specifications, while the development stage consisted of constructing the problem items based on the predetermined design and conducting expert validation to assess the feasibility of the product.

The research subjects consisted of two expert lecturers in mathematics education who served as validators. The research instrument was a validation sheet covering aspects of content relevance, problem construction, and language clarity. The assessment employed a four-point Likert scale with a maximum score of 24.

The collected data comprised both quantitative and qualitative data. Quantitative data were obtained from the expert validation scores, while qualitative data consisted of suggestions and comments from the validators, which were used as the basis for product revision. The validity percentage was calculated using the following formula:

$$P = \frac{\text{Score obtained}}{\text{Maximum score}} \times 100\%$$

The percentage results were subsequently interpreted based on validity level criteria, as presented in **Table 1**.

Table 1. Validity Interpretation Criteria

Percentage (%)	Validity Category
81 – 100%	Very Valid
61 – 80%	Valid
41 – 60%	Fairly Valid
≤ 40%	Not Valid

RESULTS AND DISCUSSION

Result

The development of spatial mathematics problems based on the context of the *Kembang Kahyangan* dance for primary school students was carried out using the ADDIE model, which was modified and limited to the development stage. The results obtained at each stage of the development process are presented as follows.

Analysis

The condition analysis was conducted through an interview with a Grade II teacher at SDN Pacing 2 Sukosewu. The results indicated that geometry instruction had not yet integrated local cultural contexts. As a result, students were not familiar with the *Kembang Kahyangan* dance, which represents one of Bojonegoro's local cultural heritages. This condition contributed to learning experiences that tended to be abstract and less contextualized. In addition, the teacher reported that several students experienced difficulties in representing two-dimensional objects. While they were able to mention and recognize the names of two-dimensional shapes, they were not yet able to visualize or draw them independently. However, when the properties of these shapes were described, students were better able to imagine and depict the intended forms. These findings indicate the need for problem designs that facilitate more structured visual and spatial representation.

Based on the condition analysis, a needs analysis was subsequently conducted. The findings revealed the necessity of developing mathematics problems that integrate local cultural

contexts and are systematically designed to support the development of students' spatial abilities in a structured manner. Therefore, spatial mathematics problems based on the context of the *Kembang Kahyangan* dance were formulated for the topic of plane figures at the primary school level.

Furthermore, the learning material analysis focused on identifying relevant two-dimensional geometry content, specifically plane figures, in Phase A, Grade II, in alignment with the outcomes of the Merdeka curriculum. The analysis confirmed that students continued to encounter difficulties in representing two-dimensional objects, particularly plane figures. These findings strengthened the rationale for developing contextualized and spatially oriented mathematics problems. The analysis of the learning material is presented in **Table 2**.

Table 2. Learning Material Analysis

Outcomes
At the end of Phase A, students are expected to recognize various two-dimensional shapes (triangles, quadrilaterals, polygons, and circles) as well as three-dimensional shapes (rectangular prisms, cubes, cones, and spheres). They should also be able to compose (combine) and decompose (break down) two-dimensional shapes such as triangles, quadrilaterals, and polygons.
Learning Objectives
<ol style="list-style-type: none"> 1. By observing images of hand movements and floor patterns in the <i>Kembang Kahyangan</i> dance, students can understand various two-dimensional shapes accurately (C2). 2. By observing images of hand movements and floor patterns in the <i>Kembang Kahyangan</i> dance, students can classify different types of two-dimensional shapes correctly (C3). 3. By examining images of floor patterns in the <i>Kembang Kahyangan</i> dance, students can analyze the composition and decomposition of one geometric shape into another accurately (C4).
Elements / Topic
Geometry / Two-Dimensional Shapes

Design

The material design was carried out by integrating the cultural context of the *Kembang Kahyangan* dance as a visual representation of two-dimensional geometric concepts. This integration was conceptual in nature, involving the mapping of hand movements and floor patterns of the dance into mathematical activities such as shape identification, classification based on similarities, and the composition and decomposition of plane figures. Thus, the contribution of this stage lies in aligning the local cultural context with the developmental structure of geometric thinking rather than in testing instructional effectiveness. The detailed relationship between the cultural context and students' mathematical activities is presented in **Table 3**.

Table 3. Ethnomathematical Study of the *Kembang Kahyangan* Dance

Cultural Context	Student Activities
Hand Movements and Floor Patterns	Identifying various plane shapes (triangle, quadrilateral, circle) by observing the hand movements and floor patterns of the <i>Kembang Kahyangan</i> dance.
Floor Patterns	Classifying various plane shapes (triangle, quadrilateral, circle) by observing the hand movements and floor patterns of the <i>Kembang Kahyangan</i> dance.
Floor Patterns	Rearranging (re-composition) and breaking down (decomposition) plane shapes by observing the floor patterns in the <i>Kembang Kahyangan</i> dance.

The design of the spatial mathematics problems was developed using the Canva application platform to produce a visually appealing layout aligned with the local cultural context. The design process considered readability, content alignment, and visual aesthetics to ensure that the problems were appropriate for primary school students. The developed product consists of six contextual open-ended problems, including two items at level 0 (visualization), two items at level 1 (analysis), and two items at level 2 (informal deduction). The problem sheet is formatted on A4-sized paper with portrait orientation, and each problem includes supporting images depicting hand movements and floor patterns of the *Kembang Kahyangan* dance. The problems use a readable font type with a font size of 16 pt to enhance clarity and accessibility for students. Furthermore, each problem item is constructed in reference to the indicators of the Van Hiele levels of geometric thinking, namely visualization, analysis, and informal deduction. The problem set also includes essential components such as a cover page, a student identity column, and instructions for completion.

At this stage, the spatial ability indicators function as a conceptual foundation for constructing the problem items rather than as direct measures of students' abilities. The distribution of indicators and problem items is presented in **Table 4**.

Table 4. Indicators of Spatial Ability According to the Van Hiele Model

Spatial Ability Level	Indicator	Question Item
Level 0 (Visualization)	Identifying geometric shapes from the hand movements of the <i>Kembang Kahyangan</i> dance.	1
	Identifying geometric shapes from the floor patterns of the <i>Kembang Kahyangan</i> dance.	2

Level 1 (Analysis)	Classifying geometric shapes from the hand movements of the <i>Kembang Kahyangan</i> dance based on shape similarity.	3
	Classifying geometric shapes from the floor patterns of the <i>Kembang Kahyangan</i> dance based on shape similarity.	4
Level 2 (Informal Deduction)	Analyzing the recomposition of two geometric shapes from the floor patterns of the <i>Kembang Kahyangan</i> dance.	5

Development

The development stage resulted in the final product in the form of a set of spatial mathematics problems based on the context of the *Kembang Kahyangan* dance, constructed according to the design specifications formulated in the previous stage. The problem development process integrated plane geometry concepts into visual representations of hand movements and floor patterns of the dance. This integration was achieved by mapping cultural elements onto spatial ability indicators based on the Van Hiele levels of geometric thinking.

In this stage, the researcher developed the problems by integrating plane figure concepts into the local cultural context of the *Kembang Kahyangan* dance. The development process was grounded in the needs analysis, learning material analysis, the Van Hiele levels of geometric thinking, and the previously established design framework. The designed problem outline resulted in six descriptive questions, detailed in **Table 5**.

Overall, the six developed problems integrating the context of the *Kembang Kahyangan* dance and primary school geometry concepts were structured progressively in accordance with the Van Hiele levels of geometric thinking. Problems 1 and 2 focus on identifying two-dimensional shapes from hand movements and floor patterns at the visualization level. Problems 3 and 4 emphasize grouping and classifying two-dimensional shapes based on similarities at the analysis level. The higher-level problems address more complex spatial reasoning tasks, such as decomposition, which correspond to the informal deduction level. This progressive structure forms a systematic spatial mathematics problem design for the topic of plane figures. The integration of the cultural context was conceptual in nature and functioned as a visual representation to connect geometric concepts with local cultural practices, namely the *Kembang Kahyangan* dance.

Table 5. Spatial Mathematics Problems

Number	Problem Focus	Indicator	Van Hiele Geometric Thinking Level Indicator
1	Identifying shapes from hand movements	Students identify two-dimensional shapes from dance hand movements (C2)	Level 0 (Visualization)

2	Identifying shapes from floor patterns	Students identify two-dimensional shapes from floor patterns (C2)	Level 0 (Visualization):
3	Grouping shapes from hand movements	Students classify two-dimensional shapes based on similarity (C2)	Level 1 (Analysis)
4	Grouping shapes from floor patterns	Students classify two-dimensional shapes based on similarity (C2)	Level 1 (Analysis)
5	Grouping shapes from floor patterns	Students classify two-dimensional shapes based on similarity (C2)	Level 2 (Informal Deduction)
6	Decomposition of shapes	Students analyze the decomposition of two-dimensional shapes (C4)	Level 2 (Informal Deduction)

A complete explanation of the spatial mathematics problems can be accessed via the QR code provided in **Figure 1**.



Figure 1. QR Code for Spatial Mathematics Problems

Following the development process, product validation was conducted to assess the feasibility of the spatial mathematics problems developed in the previous stage. The validation process involved two expert lecturers in mathematics education who served as validators and used a validation sheet covering aspects of content appropriateness, problem construction, and language clarity. The results indicated that validator 1 awarded a score of 23 out of a maximum of 24 (95.83%), while validator 2 awarded a score of 22 out of 24 (91.67%). Based on the validity interpretation criteria, these scores fall within the “very valid” category, indicating that the developed spatial mathematics problems are feasible in terms of content and construction for subsequent stages of development.

In addition to the quantitative assessment, the validators provided several suggestions for improvement, including the addition of cognitive level specifications to the problem indicators, the inclusion of answer columns for each item, and the simplification of sentence structures to better match students’ cognitive levels. These suggestions were used as the basis for product revision to produce a more systematic final product aligned with the Van Hiele spatial indicators.

Discussion

The spatial mathematics problems were developed by integrating the local cultural element of the *Kembang Kahyangan* dance as a visual representation to facilitate the development of spatial thinking activities based on the Van Hiele levels of geometric thinking. This study focuses on developing a problem design that aligns with Van Hiele spatial ability indicators rather than testing effectiveness or empirically measuring students' abilities. Fitriza et al. (2022) emphasize that the utilization of local culture through an ethnomathematics approach can serve as a conceptual framework for designing learning activities based on spatial abilities. Expressed by Koyuncu (2022) in Türkiye, who states that culture, including dance, can be used as a resource in the development of geometry learning designs.

The development of spatial mathematics problems was designed in accordance with the Merdeka curriculum to ensure alignment with the characteristics of primary school students. The material focused on the concept of plane figures as part of geometry learning in Phase A. The problems were constructed based on a previously designed blueprint and by considering the stages of students' spatial abilities according to the Van Hiele levels of geometric thinking. This study is similar to Fauzan and Mariana's study (2023), which emphasizes the importance of aligning mathematics problem design with the Van Hiele levels of geometric thinking. Therefore, the developed problems are relevant in terms of content and contextual in nature, as they integrate local cultural elements through the *Kembang Kahyangan* dance. Consequently, this study contributes to the development of ethnomathematics-based problem design in primary school geometry (Sangadah et al., 2025; Zulkifli & Rahmawati, 2020).

Furthermore, the study by As'ari & Kusaeri (2024) demonstrates that local culture, such as *Kendi Maling Banyumulek*, can be used as a contextual basis for designing mathematics problems to analyze students' spatial abilities. In contrast to that study, the present research does not focus on measuring students' spatial abilities; rather, it emphasizes the systematic development of spatial mathematics problem designs structured according to the Van Hiele levels of geometric thinking.

The problem design encompasses various student activities, including identifying plane figures, grouping plane figures based on shared characteristics, and analyzing composition and decomposition relationships among plane figures through observation of hand movements and floor patterns. Each problem corresponds to the Van Hiele levels of geometric thinking, ranging from level 0 (visualization) to level 2 (analysis). This approach aligns with the hierarchical principles of Van Hiele's theory, which emphasize that students' geometric thinking develops progressively and systematically (Naufal et al., 2021).

The first and second problems at level 0 (visualization) involve activities requiring students to identify plane figures through observation of dance hand movements and floor patterns. This activity emphasizes recognizing shapes based on their visual appearance without in-depth analysis of their properties. Jainuri et al. (2025), state that local cultural contexts can assist students in identifying geometric shapes through visual observation processes. At this stage, the cultural context functions as a visual stimulus that connects concrete experiences with basic geometric concepts.

The third and fourth problems at level 1 (analysis) require students to group plane figures based on similarities in characteristics observed from the hand movements and floor patterns.

Grouping activities are considered an effective way to classify objects according to shared characteristics (Hapsari, 2020). Conceptually, this stage represents a shift from mere shape recognition toward the analysis of geometric properties.

Furthermore, in the fifth and sixth problems at level 2 (informal deduction), students are required to analyze the composition and decomposition of plane figures through dance floor patterns. Mytha et al. (2024) argue that introducing plane figures through floor patterns can facilitate the understanding of abstract concepts. At this level, students are guided to construct simple reasoning about relationships among shapes rather than merely naming them.

The fifth and sixth problems are categorized as higher-order thinking problems because these problems involve analysis and drawing conclusions. However, within the context of this study, this categorization is understood as a characteristic of the problem design rather than as a measurement of students' higher-order thinking skills (HOTS). Wati & Widiana (2024) state that the integration of local culture has the potential to support the development of HOTS.

Conceptually, the integration of local culture into the design of spatial mathematics problems provides a more concrete context for representing geometric concepts. This perspective aligns with the view of Jean Piaget regarding the importance of concrete experiences for primary school students (Babakr et al., 2019; Sari et al., 2025).

Overall, the findings of this study contribute to the development of theoretically structured and expert-validated ethnomathematics-based mathematics problem design. The study demonstrates that local cultural contexts can be systematically integrated into the design of spatial mathematics problems for primary school students, thereby addressing the research objective of producing spatial mathematics problems based on the context of the *Kembang Kahyangan* dance as an application of ethnomathematics in primary education.

CONCLUSION

This study produced spatial mathematics problems based on the local cultural context of the *Kembang Kahyangan* dance, designed for primary school students. The development process followed the ADDIE model up to the development stage, considering the results of condition, needs, and material analyses aligned with the outcomes of the Merdeka curriculum. The integrated material focused on the concept of plane figures, structured according to the Van Hiele theory of geometric thinking levels, ranging from visualization to informal deduction. The validation results from two expert lecturers indicated that the developed product fell within the "very valid" category, with percentages of 95.83% and 91.66%, respectively.

These findings indicate that the developed problem design is feasible to be used as a prototype for ethnomathematics-based spatial mathematics problem development. Conceptually, this development contributes to mathematics learning activities by systematically integrating local cultural context with the Van Hiele levels of geometric thinking. The resulting product has the potential to support more contextual geometry learning by addressing students' spatial abilities while enriching the development of culture-based problem design within ethnomathematics studies.

However, several limitations should be acknowledged. First, the scope of this study was limited to the development stage and did not include broader implementation. Second, the product

feasibility was assessed only in terms of validity, without examining its practicality or effectiveness. Therefore, future research is recommended to conduct broader field testing with students to measure the practicality and effectiveness of the developed product, namely spatial mathematics problems based on the context of the Kembang Kahyangan dance, Bojonegoro.

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