

The Ethnomathematics of the Kawung Batik Motif as a Context for Learning Geometric Transformations: A Contextual Instructional Design with Transfer to Tulungagung Batik

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Abstract. Ethnomathematics provides a context for connecting school mathematics with students' cultural environments. This article develops a conceptual instructional design for geometric transformation using the Yogyakarta Kawung batik motif as an initial context and Tulungagung batik motifs as a transfer context. The study employs a conceptual approach based on a synthesis of literature on ethnomathematics, mathematical characteristics of batik, batik-based mathematics learning, Tulungagung batik, and relevant curriculum documents. The resulting design comprises six stages: cultural observation, guided exploration, mathematization and modeling, formalization, transfer to the Tulungagung batik context, and reflection and assessment. The design connects repetition, symmetry, positional relationships, and changes in size to translation, reflection, rotation, and dilation on the Cartesian plane. It contributes a systematic pedagogical trajectory from cultural observation to mathematical formalization and application across cultural contexts, aligned with geometric transformation learning in Phase D.

Keywords: ethnomathematics; Kawung batik; geometric transformation; instructional design; context transfer; Tulungagung batik

1 Introduction

Mathematics does not develop in isolation from human life. Human activities in diverse social and cultural environments give rise to practices involving measurement, classification, patterns, space, and change. This perspective forms one of the foundations of ethnomathematics, which situates mathematical activities within the social and cultural contexts in which they develop [1,2].

In mathematics education, the relationship between culture and mathematics has considerable pedagogical potential. Ethnomathematics can be used not only to identify mathematical ideas embedded in cultural practices but also to serve as a bridge between students' prior experiences and knowledge and the formal mathematics taught in school [3]. Culture can therefore serve as an initial context that helps students observe, describe, and reason about structures before representing them in more formal mathematical terms. This perspective is consistent with the concept of mathematization in Realistic Mathematics Education, which

positions contextual experiences as a starting point from which students gradually construct and formalize mathematical knowledge rather than receiving formal concepts directly [4,5].

Batik is one aspect of Indonesian culture with considerable potential for mathematics education. Batik patterns are constructed through repetition, symmetry, the arrangement of shapes, and spatial relationships among elements. Various studies have examined batik patterns through geometric concepts and geometric transformations. Yogyakarta batik patterns, for example, have been analyzed using geometric concepts while also serving as a context for learning about cultural values and knowledge [6].

More specifically, the Yogyakarta Kawung batik motif has been studied from an ethnomathematical perspective. A qualitative descriptive study of Kawung-patterned batik fabric demonstrated that elements of the Kawung motif can be mathematically represented as elliptical shapes and that a single motif element can be reconfigured using geometric transformations [7]. These findings indicate that visual characteristics of the Kawung motif, such as repetition, regularity of arrangement, and relationships among elements, can serve as a starting point for exploring changes in position and shape from a mathematical perspective. However, identifying a relationship between the structure of a motif and mathematical concepts does not, by itself, explain how such a context can be translated into a systematic learning experience.

In line with this perspective, a hypothetical learning trajectory was developed for teaching rotation using the Kawung batik motif through a design research approach involving seventh-grade junior high school students [8]. The design showed that students could move from freely drawing the Kawung motif toward discovering the rotation formula by recording the initial and final positions of the rotated points. This study provides empirical evidence that the Kawung motif can be translated into a learning trajectory for a specific type of transformation. However, its scope is limited to rotation and does not include an explicit transfer stage to a second cultural context. The present article seeks to extend this scope by covering all four types of single geometric transformations and incorporating a transfer stage using batik from another region. Consequently, the resulting design remains conceptual and has not yet been empirically tested through design research [8].

Research on the use of batik in mathematics education continues to develop. Batik motifs have been used in various ethnomathematics studies as contexts for exploring mathematical concepts [9]. Research specifically examining the teaching of geometric transformations using batik motifs has also highlighted the potential of batik as a context for learning transformations [10]. Other studies have documented the development of ethnomathematics research involving various Indonesian batik motifs [11]. Nevertheless, most ethnomathematics studies employ qualitative and descriptive approaches to explore cultural objects, while studies that demonstrate more concretely how such objects can be used in classroom learning remain limited [12]. There is therefore still a need for research that explains more explicitly how the results of ethnomathematical exploration can be organized into a sequence of learning activities that guides students from observing cultural objects toward understanding and applying mathematical concepts. This issue provides the starting point for the present article. The existence of a connection between cultural objects and mathematical concepts does not automatically lead to meaningful learning. Teachers still need an instructional plan that explains how students observe objects, recognize patterns, formulate conjectures, represent their observations, model them mathematically, formalize concepts, and apply those concepts to other situations. The relevant question is therefore not limited to identifying which mathematical concepts can be explored through batik motifs, but also concerns how these motifs can be used to construct a learning trajectory toward formal mathematical understanding. This question is

consistent with the concept of a learning trajectory in the Realistic Mathematics Education approach, which emphasizes a gradual progression from informal activities toward mathematical representation and formalization [5].

The curriculum context also provides opportunities for developing such learning. According to Decision No. 046/H/KR/2025 of the Head of the Agency for Educational Standards, Curriculum, and Assessment concerning Learning Outcomes, students in Phase D are expected to perform single transformations, including reflection, translation, rotation, and dilation, on points, lines, and plane figures in the Cartesian coordinate plane and to use these transformations to solve problems [13]. Batik motifs can therefore serve as a context for helping students develop an understanding of translation, reflection, rotation, and dilation before and during their representation on the coordinate plane. In this context, the cultural setting is not an end in itself but rather a means of supporting the achievement of the mathematics competencies defined in the curriculum.

In addition to curricular alignment, incorporating local contexts provides opportunities to connect learning with students' cultural environments. Tulungagung has a batik tradition that dates back to the Majapahit Kingdom. During this period, the region, previously known as Bonorowo, began to embrace batik through interactions with Majapahit troops. The tradition later flourished in several key villages, including Sembung, Majan, Mojosari, and Bangoan, with approximately 86 distinctive batik motifs documented to [14, 15]. [16] examined geometric concepts in the Sekar Jagad motif of Gajah Mada batik from Tulungagung, while [17] analyzed Gajah Mada batik motifs using the concepts of translation, rotation, and reflection. Thus, the Sekar Jagad motif is among the Tulungagung motifs for which relatively comprehensive mathematical documentation is available. Furthermore, [18] notes the presence of Kawung Picis within the repertoire of classic Tulungagung batik motifs. The term "picis" forms part of the naming convention for Kawung variants based on size, namely picis, bribil, sen, and kemplong, which refer to denominations of old currencies widely recognized in various batik-producing regions of Java. These findings indicate that the Kawung tradition is also present and documented within the Tulungagung batik repertoire, but they do not imply that the motif originated exclusively in this region. Overall, the findings suggest that local Tulungagung batik can provide an alternative context for observing and modeling mathematical structures.

In this article, the Kawung batik motif is used as the initial context because its visual characteristics have been documented in ethnomathematics studies, while Tulungagung batik, with the Sekar Jagad motif from Gajah Mada batik as the primary transfer context, is used for the transfer stage. The selection of these two contexts is not intended to compare or contrast the two batik traditions. Rather, the shift from one context to another is designed to give students an opportunity to apply the concept of transformation they have learned to different visual structures that are closer to their own cultural environment.

Based on the discussion above, this article aims to describe the characteristics of the Yogyakarta Kawung batik motif that can be used as a context for modeling geometric transformations and to develop an ethnomathematics-based instructional design for geometric transformations that links the Kawung motif as the initial context with Tulungagung batik as the transfer context. The contribution of this article does not lie in identifying a new relationship between the Kawung motif and geometric transformations, as this relationship has already been discussed in previous research, including an empirically tested learning trajectory for rotation. Rather, its main contribution lies in developing a broader pedagogical pathway that encompasses all four types of single transformations and connects cultural observation, pattern exploration, mathematization and modeling, conceptual formalization, transfer to new contexts, and reflection and assessment.

2 Methods

This article employs a conceptual study approach based on a synthesis of relevant literature to develop an ethnomathematics based lesson plan for geometric transformations. The study is not intended to evaluate the effectiveness of the instruction through field research. Therefore, it does not involve classroom observations, interviews, or learning outcome measures. The lesson plan was developed through the interpretation and synthesis of relevant scholarly literature and mathematics curriculum documents.

The literature review focused on four groups of sources. The first group consisted of conceptual literature on the relationship between mathematics, culture, and ethnomathematics, including the foundations of mathematization in Realistic Mathematics Education. The second group comprised empirical studies on the mathematical characteristics of batik motifs, particularly Kawung and Yogyakarta batik. The third group included studies on the use of batik in mathematics education and on geometric transformations, including empirically tested instructional design research. The fourth group consisted of sources supporting the selection of Tulungagung batik as a transfer context, together with official documents concerning the learning requirements for geometric transformations at the school level.

The literature search was conducted through Google Scholar and relevant scientific publications using keywords such as “ethnomathematics,” “batik,” “geometric transformations,” “culture based mathematics education,” and “batik mathematics.” The literature primarily considered publications from 2015 to 2025, while several earlier conceptual works were also included as theoretical foundations. The search was purposive and did not follow a systematic review protocol that documented the number of sources at each screening stage. Accordingly, this study is positioned as a conceptual study based on literature synthesis rather than as a systematic literature review.

Sources were included in the synthesis when they explicitly addressed at least one of three aspects: the relationship between culture and mathematics, the mathematical characteristics of batik patterns, or the use of cultural contexts in mathematics education. Literature that did not contribute directly to the development of the instructional design was not used as a primary basis for the synthesis.

The analysis was conducted thematically. The first stage identified visual characteristics of the motifs that could provide contexts for exploring translation, reflection, rotation, and dilation. The second stage examined how observations of visual structures could be connected to mathematical representations. The third stage mapped the results of the synthesis onto the learning requirements for geometric transformations in Phase D Mathematics. The fourth stage used these findings to develop a sequence of learning activities linking cultural contexts with exploration, mathematization, formalization, application in new contexts, and reflection.

In this study, the relationship between batik patterns and geometric transformations is understood as the result of mathematical modeling of visual structures. Pattern identification is therefore not treated as evidence that the original pattern designers historically employed formal definitions or terminology related to geometric transformations. This distinction separates pedagogical interpretations of cultural objects from historical claims about the knowledge or creative processes of their makers.

The results of the synthesis were then used to develop a six stage instructional design. The output of the study is a conceptual design rather than empirical evidence of the effectiveness of a particular instructional model. The resulting design is therefore intended to provide a foundation for the development of instructional materials, expert validation, readability testing, practicality testing, and subsequent implementation research.

3 Results

3.1 The Kawung Motif as a Mathematical Context



Fig. 1. The Yogyakarta Kawung batik motif, featuring repetitive patterns and an arrangement of elliptical elements.

The synthesis indicates that the Kawung motif has visual characteristics that can potentially serve as a context for learning geometric transformations. Its elements are arranged repetitively and exhibit regularity in terms of position, arrangement, and symmetry. These characteristics provide visual objects that students can observe before formal mathematical concepts are introduced.

In this lesson plan, learning does not begin by labeling geometric changes as translation, reflection, rotation, or dilation. Introducing these terms from the outset may encourage students to simply match visual forms with mathematical labels. Instead, students are first guided to observe patterns, compare elements, and describe the changes they notice. They may consider whether a shape reappears in a different position, whether its size and orientation remain unchanged, whether two elements have a relationship similar to that between an object and its reflection across a line, or whether a change in position can be explained by rotation around a point.

The initial process of attending to patterns in cultural objects is referred to in this article as “cultural noticing.” The term is used operationally to describe how students begin to notice elements, patterns, and relationships in cultural objects that can subsequently become the focus of mathematical reasoning. It is not adopted as an established concept from a particular source but is used to name the initial stage of the learning process developed in this study. Cultural noticing is therefore not the final objective but serves as a starting point for further exploration and mathematization.

The next stage involves mathematization, in which students connect their observations with changes that can be modeled mathematically. Repeated elements appearing in different positions can provide a context for exploring translation. Symmetrical relationships can provide a context for reflection. Changes in position relative to a particular center and angle can be used to explore rotation. Changes in size while preserving the overall shape can serve as a context for modeling dilation.

After these relationships have been explored visually, students are guided to work with simplified shapes or selected elements adapted from the batik patterns on the Cartesian coordinate plane. Visual observations are thus gradually connected to points, coordinates,

directions of change, centers of transformation, and transformation rules. This transition supports movement from contextual representations toward more formal mathematical representations.

The cultural context, however, needs to remain proportionate to the mathematical content being taught. The presence of patterns that can be modeled using geometric transformations does not, by itself, indicate that the motif's creator consciously employed formal mathematical concepts such as translation, reflection, rotation, or dilation. Accordingly, the Kawung motif is treated in this study as a context for mathematically modeling visual structures rather than as historical evidence of the creator's knowledge of formal mathematics.

The Kawung context is subsequently connected to the learning of geometric transformations on the Cartesian coordinate plane, in accordance with the learning requirements of Phase D Mathematics. The cultural context therefore functions as an entry point for developing specific mathematical competencies.

The relationship between the cultural context, student activities, and mathematical concepts in the instructional design is summarized in Table 1.

Table 1. Relationship among Cultural Context, Learning Activities, and Mathematical Concepts

No	Stage	Student Activities	Mathematical Focus	Intended Outcome
1	Cultural Observation (Cultural Noticing)	Observe the structure, repetition, and regularity of the Kawung motif	Patterns, spatial relationships, symmetry	Identify regularities
2	Guided Exploration	Compare the position, size, and orientation of motif elements	Conjectures about change and transformation	Identify characteristics of change
3	Mathematization and Modeling	Connect visual patterns with transformation models and coordinate representations	Translation, reflection, rotation, dilation, and coordinates	Formulate and test mathematical conjectures
4	Concept Formalization	Determine and explain transformation rules	Rules and symbolic representations	Connect visual and formal representations
5	Context Transfer	Apply the concepts to Tulungagung batik motifs	Application and generalization of concepts	Apply concepts in a new context
6	Reflection and Assessment	Explain strategies, reasoning, and modeling results	Reasoning, representation, and mathematical communication	Communicate and reflect on understanding

The mapping shows that the use of culture in learning does not stop at introducing a context. Instead, culture becomes part of the process of observation, conjecture formation, modeling,

application, and reflection. The motifs therefore function not merely as visual illustrations but as part of a trajectory through which students develop mathematical understanding. The sequence of these six stages is summarized visually in Figure 2.

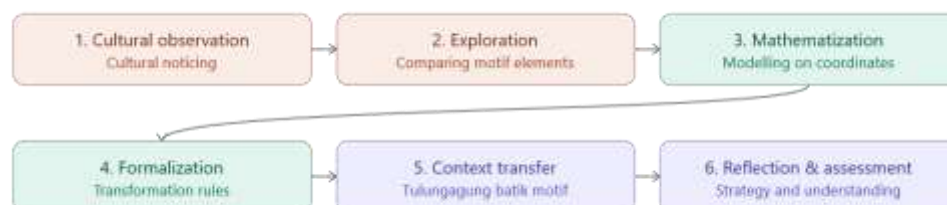


Fig. 2. A six stage instructional design for geometric transformations based on the Kawung motif.

3.2 Instructional Design from Cultural Context to Formalization

Based on the literature synthesis, the instructional design consists of six stages. The design provides a learning pathway that progresses from observing cultural objects to using formal mathematical concepts and applying them in a new context. Because this is a conceptual design, the time allocation for each stage is not rigidly specified in terms of a fixed number of class periods. A realistic allocation, including the possibility that the transfer and assessment stages may require more than one session, should be determined after the instructional materials have been developed and piloted. This consideration is important because the time and workload required for each stage may vary according to classroom characteristics.

Stage 1: Cultural Observation. The teacher presents the Kawung motif clearly enough for students to observe repetition, positional relationships, and regularity among its elements. At this stage, the teacher does not yet introduce the term “geometric transformation.” Instead, students are guided through open ended questions such as: Which elements are repeated? What is the same and what is different between two elements? How does the position of one element compare with that of another? Is there a symmetry relationship? This stage gives students an opportunity to examine the structure of the pattern before identifying the relevant mathematical concepts. These initial observations provide the foundation for further exploration in the next stage.

Stage 2: Guided Exploration. Students work individually or in small groups to compare different elements of the pattern. They examine the position, size, shape, and orientation of the elements and describe the changes they observe. The teacher facilitates the process by asking questions that encourage students to examine and test their conjectures. For example, students may be asked to determine whether a shape has simply moved, whether its orientation has changed, whether a line can explain the relationship between two shapes, or whether changes in size follow a particular pattern. This stage allows students to develop conjectures before formal mathematical concepts are introduced. Mathematical terminology is then introduced as a more precise way of describing the relationships students have already observed.

Stage 3: Mathematization and Modeling. At this stage, students connect their observations with the concept of geometric transformations. A change in position without a change in shape, size, or orientation can be modeled as a translation. The relationship between an object and its image across a line can be modeled as a reflection. A change in position

determined by a center and an angle can be modeled as a rotation. A change in size according to a specific scale factor can be modeled as a dilation. Students then use simple shapes or selected elements adapted from the motif to construct models on the Cartesian coordinate plane. For example, a single unit of the Kawung motif, which can be mathematically approximated as an arrangement of ellipses or trapezoids around a central point [7] can be simplified into a single ellipse or trapezoid and placed on the coordinate plane as the initial object for modeling.

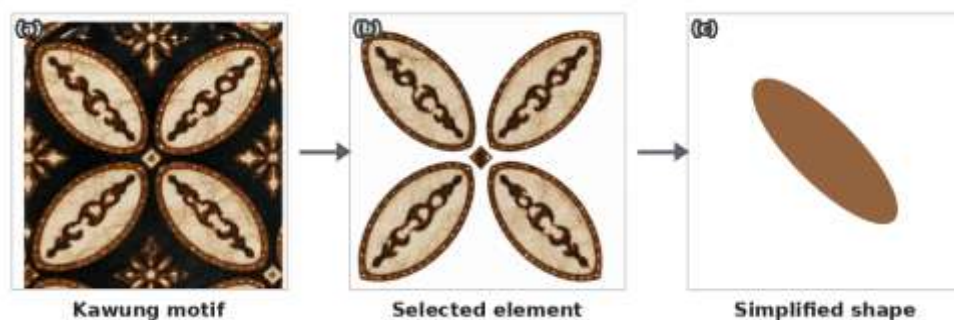


Fig. 3. Simplification process from the Kawung motif to a selected element and a simplified geometric shape.

Simplifying the shapes is necessary to prevent the visual complexity of the pattern from distracting students from the transformation concepts being learned. The simplified shapes can then be placed on a coordinate plane and subjected to one of the transformations, as illustrated in Figure 4.

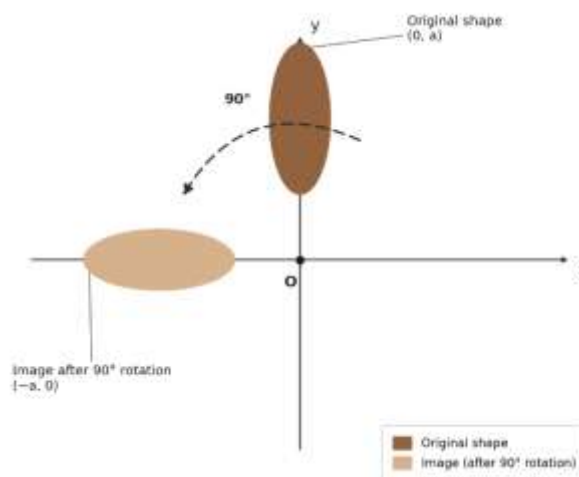


Fig. 4. An example of a simplified Kawung element modeled on a coordinate plane, showing the original shape and its image after a 90° rotation about the center point.

In the development of future learning materials, the same principle illustrated in Figure 4 can be applied to translation, reflection, and dilation so that students can work with practical examples of all four types of single geometric transformations.

Stage 4: Concept Formalization. Students are guided to identify the relationship between the original object and its image by examining changes in their coordinates. Based on these patterns of change, students formulate or apply the appropriate transformation rules. This formalization stage connects the visual experiences from the previous stage with symbolic representations. Students are expected not only to identify the type of transformation but also to explain the rule underlying it. For example, after examining the displacement of points in a shape as illustrated in Figure 4, students can describe the relationship between the coordinates of an original point and those of its image. For a 90° counterclockwise rotation about the origin, this relationship follows the rule:

$$(x, y) \rightarrow (-y, x)$$

Step 5: Adaptation to the Tulungagung batik context. After developing an understanding of geometric transformations through the Kawung context, students are introduced to the Sekar Jagad motif from Gajah Mada Tulungagung batik as the primary transfer context.



Fig. 5. The Sekar Jagad motif from Gajah Mada Tulungagung batik.

The motif is selected because relatively comprehensive mathematical documentation is available for it among the Tulungagung batik motifs identified in the sources used in this study [16, 17]. Students are asked to identify relevant patterns, determine which shapes or elements should be analyzed, formulate conjectures about the transformations that may explain the relationships among elements, and justify those conjectures using mathematical reasoning.

As an optional extension for classes with additional time, the teacher may also introduce the Kawung Picis motif, one of the Kawung variants documented in the classical Tulungagung batik tradition [18]. This additional context allows students to compare how transformation concepts can be applied to motif forms with different visual characteristics.

Students then compare their analysis of the Tulungagung motif with their earlier experience of working with the Kawung motif. In this way, the second context functions not merely as a change of visual material but as an opportunity for students to apply and generalize the concepts they have learned to a different visual structure.

Stage 6: Reflection and Assessment. The final stage is designed to assess students' understanding of geometric transformations and the modeling process. Students are asked to explain what changes and what remains unchanged when an object undergoes a transformation. They also explain the strategies they used to identify the type of transformation and the reasoning underlying their answers. The assessment addresses students' understanding of geometric transformations and their ability to connect visual patterns with mathematical representations. Mathematical understanding can be observed through their ability to identify transformations, determine the coordinates of transformed objects, apply appropriate transformation rules, and provide mathematical justifications. Their modeling ability can be examined through the accuracy with which they select relevant objects, identify the relationships being analyzed, construct representations on the coordinate plane, and explain the connection between the visual context and the mathematical model.

Overall, the instructional design follows the sequence:

observe → explore → mathematize and model → formalize → transfer → reflect

3.3 Contextual Transfer and Learning Assessment

Transfer is a crucial component of the proposed design. After students develop an understanding of geometric transformations through the Kawung motif, they are guided to apply the same concepts to the Sekar Jagad motif from Gajah Mada Tulungagung batik. This transfer gives students an opportunity to apply their developing knowledge when encountering a different visual representation. This approach is consistent with the view that transfer occurs when learning in one context influences performance in another related context and that effective transfer generally requires explicit metacognitive reflection to prevent learning from remaining at a superficial level of recognition [19].

The transfer process follows a sequence from the Kawung batik context to exploration and modeling of transformations, conceptual formalization, transfer to the Tulungagung batik context, and application and explanation of the concepts.

During the transfer activity, the guiding question shifts from “What transformations can be identified in the pattern?” to “How can the transformation concepts that have been learned be used to explain the structures of different patterns?” This shift encourages students to use concepts reflectively rather than merely recognize and name transformation types. The activity is consistent with the concept of mindful transfer, which emphasizes the conscious application of knowledge when learners encounter different situations or contexts rather than simply reproducing patterns practiced with similar stimuli [19].

The selection of Tulungagung batik also creates an opportunity to connect mathematics learning with students' local cultural environment. Students can use mathematical ideas to observe and explain visual structures found in cultural products around them. In this context, culture provides the setting for mathematical activity, while mathematics provides tools for interpreting and modeling specific structures in cultural objects.

However, the use of local cultural contexts requires clear interpretive boundaries. The existence of patterns that can be modeled mathematically does not mean that the creators of those motifs historically used the same formal definitions or procedures found in school mathematics. Therefore, the learning activities focus on how students can use contemporary mathematical concepts to model visual structures rather than on drawing conclusions about the formal mathematical knowledge of the motif creators.

4 Discussion

4.1 From Ethnomathematical Identification to Instructional Design

One important contribution of ethnomathematics research is its demonstration that cultural practices and artifacts can be examined through a mathematical lens. In the context of batik, various studies have identified relationships between motifs and geometric concepts. However, such identification does not automatically result in an instructional design. This observation is consistent with findings that many ethnomathematics studies continue to focus on descriptive explorations of cultural objects [12].

The design presented in this article seeks to extend the role of ethnomathematical findings from identifying mathematical elements to informing the design of learning experiences. The Kawung motif is not simply presented as an illustration after the concept of transformation has been explained. Instead, it is introduced at the beginning of the learning process so that students can observe patterns, compare changes, formulate conjectures, and develop representations before formal concepts are introduced. This approach complements, rather than replaces, the precedent established by previous design research on rotation using the Kawung motif [8]. The present design differs primarily in its broader scope, which covers four types of geometric transformations and includes an explicit transfer stage to a second cultural context.

This approach is also consistent with the view that connections between informal knowledge and formal mathematics need to be developed through the learning process. Students may begin with everyday expressions such as describing a shape as “shifting,” “like a mirror image,” or “rotating.” These informal descriptions can then be gradually refined into formal mathematical terminology and representations.

Within this framework, mathematization is understood as a gradual process that connects selected aspects of contextual objects with mathematical representations and structures. This interpretation is consistent with the concepts of horizontal and vertical mathematization in Realistic Mathematics Education, involving movement from contextual situations to informal models and then from informal models to formal mathematical structures and procedures [4,5]. Students are not immediately expected to derive formulas from complex patterns. Instead, they first identify relevant relationships, simplify objects when necessary, construct representations, and use those representations to explain the transformations involved.

4.2 Context Transfer and the Role of Culture in Learning

The use of Tulungagung batik as a second context serves a purpose beyond simply adding variety to the learning materials. After students have developed an understanding of transformations through the Kawung motif, they encounter a different visual structure and are asked to apply the same concepts to explain the relationships they identify.

This transition provides students with an opportunity to recognize that geometric transformations are not limited to a particular figure or pattern. Rather, the concepts can be used as mathematical tools to analyze a range of structures that exhibit relevant characteristics.

In this design, the second context also strengthens the connection between mathematics learning and students’ cultural environment. Batik is not merely an image intended to make learning more engaging but an object that can be observed, modeled, and interpreted through mathematics. This approach is consistent with culturally responsive mathematics education, which emphasizes the importance of enabling students to interpret and understand their cultural

environment through mathematical tools rather than simply presenting cultural contexts that are disconnected from their experiences [20, 21].

Nevertheless, cultural contexts need to be approached critically. Not every cultural pattern should be forced to represent a particular mathematical concept. The selection of motifs should consider the clarity of their visual structures and their alignment with the learning objectives. Mathematical modeling of visual patterns should also be distinguished from claims about their history, philosophical meanings, or the processes through which the motifs were created.

This distinction is particularly important when a pattern appears to involve changes in size. Such changes can provide a context for modeling scale and dilation when their mathematical relationships can be clearly established. However, visual changes alone are not sufficient to conclude that batik artists consciously applied the formal mathematical concept of dilation.

4.3 Curriculum Alignment and the Contribution of the Instructional Design

The instructional design is directly related to the learning of geometric transformations on the Cartesian coordinate plane in Phase D Mathematics, as stipulated in Decision No. 046/H/KR/2025 of the Head of the Agency for Educational Standards, Curriculum, and Assessment [13]. This alignment shows that the use of cultural contexts does not reduce the mathematical demands of the learning process. Rather, cultural contexts are used to help students develop a pathway toward the competencies specified in the curriculum.

The contribution of this article does not lie in claiming that the relationship between the Kawung motif and geometric transformations is newly discovered or that the motif has never been incorporated into a learning trajectory. Both aspects have been addressed in previous studies, including an empirically tested learning trajectory focused on rotation using the Kawung motif [8]. The contribution of the present article lies instead in its broader scope, which encompasses four types of single geometric transformations and explicitly incorporates transfer to a second cultural context within a single learning pathway. The proposed pathway progresses from cultural context and cultural noticing to pattern exploration, mathematization and modeling, formalization, context transfer, and reflection and assessment. This approach shifts the focus from asking “What mathematical concepts are present in the motif?” toward a more operational pedagogical question: “How can motifs be used to help students construct, formalize, and apply mathematical concepts?”

Accordingly, the contribution of the article is primarily conceptual and instructional. The resulting design can serve as a basis for developing instructional materials, student worksheets, learning media, and culturally contextualized assessment tools. At the same time, a conceptual design cannot by itself be regarded as evidence of instructional effectiveness. This article does not examine improvements in students’ learning outcomes, representational skills, mathematical reasoning, or attitudes. Such claims require empirical investigation. In this respect, the design extends the scope of previous empirical work on the Kawung motif, which focused specifically on rotation [8].

4.4 Limitations and Directions for Further Research

The proposed design remains conceptual and has not yet been tested through classroom implementation. Consequently, this article does not provide empirical evidence regarding its validity, practicality, or effectiveness. Further research is needed to validate the appropriateness of the cultural contexts, learning objectives, activities, representations, and assessment procedures through a design research approach. Such research can build on the precedent

established by [8] while extending the focus to all four types of geometric transformations and the explicit use of contextual transfer.

Another limitation concerns the selection and interpretation of motifs. Not every motif variation is equally suitable for illustrating every type of transformation. The selection of cultural objects should therefore consider the clarity of their visual structures, their alignment with the intended mathematical concepts, and the extent to which they can be simplified into representations suitable for the Cartesian coordinate plane.

Visual documentation is also important in the development of instructional materials. Images of motifs should be obtained from reliable sources, and their use should comply with applicable licensing and copyright requirements. Information concerning the history and cultural significance of motifs should likewise be supported by appropriate sources rather than inferred solely from mathematical interpretations.

Future research can develop this design through expert validation, readability testing, the development of student modules or worksheets, practicality testing, and classroom implementation. Empirical studies are also needed to examine how students attend to cultural patterns, how they move from informal descriptions to formal mathematical representations, and how the second cultural context supports the application and generalization of transformation concepts in new situations.

4 Conclusion

The ethnomathematics of batik motifs can provide a meaningful context for learning geometric transformations when its use extends beyond the identification of mathematical concepts in cultural objects. This article presents a six stage conceptual instructional design consisting of cultural observation, guided exploration, mathematization and modeling, conceptual formalization, transfer to the Tulungagung batik context, and reflection and assessment.

The design uses the Kawung batik motif as an initial context for observing patterns and visual relationships that can subsequently be modeled through translation, reflection, rotation, and dilation. The learning process then moves toward representation on the Cartesian coordinate plane and the formalization of transformation rules.

Tulungagung batik serves as a second context in which students can apply the transformation concepts they have learned to different visual structures that are more closely connected to their cultural environment. Thus, culture is not used merely to introduce mathematical concepts but is incorporated into the broader process of observation, modeling, application, and reflection.

The main contribution of the article lies in developing a pedagogical pathway that connects cultural observation with formal mathematics through a systematic sequence covering four types of single geometric transformations and explicit transfer to a different cultural context. The design builds on previous work involving a Kawung based learning trajectory for rotation while extending the scope of transformation types and introducing contextual transfer.

Because the present study is conceptual in nature, the proposed design requires further development through instructional material design, expert validation, and empirical testing. Such research is needed to examine its validity, practicality, and effectiveness as a basis for culturally contextualized mathematics learning.

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