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Integrating Batik-Based Ethnomathematics with the RADEC Model in Fifth-Grade Geometry Learning: A Qualitative Study

Ikrima Romadhona Maqhfiroh[1], Beti Istanti Suwandayani[2*]
[1,2]Universitas Muhammadiyah Malang, Malang, Indonesia

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ABSTRACT

Purpose: This study aims to examine the implementation of the Read, Answer, Discuss, Explain, and Create (RADEC) model integrated with batik-based ethnomathematics in fifth-grade geometry learning and to explore students' learning activities and the challenges emerging during the learning process. The study addresses the need for contextual mathematics learning that connects geometric concepts with students' cultural experiences through meaningful learning activities. **Methods:** This study employed a qualitative descriptive design conducted in a fifth-grade class at MI Senden, Indonesia. The participants consisted of one fifth-grade teacher and 18 students. The implementation was carried out in one learning session comprising four lesson periods (140 minutes). Data were collected through structured classroom observations, semi-structured interviews, and artifact analysis of student worksheets and batik motif designs. Data were analyzed through an interactive process of data condensation, data display, and conclusion drawing. Data credibility was established through source and technique triangulation. **Findings:** The findings reveal that the integration of batik-based ethnomathematics within the RADEC sequence was characterized by a gradual process of identifying, discussing, explaining, and applying geometric concepts. At the beginning of the learning process, students demonstrated recognition of common geometric shapes but encountered difficulties in articulating their properties and distinguishing visually similar shapes. The Discuss and Explain stages provided opportunities for students to exchange ideas and communicate their understanding, while the Create stage became a context for students to connect geometric properties with batik motif construction. Student activities during the Create stage were characterized by the identification and combination of geometric shapes in student-generated batik designs. However, the implementation was constrained by limited instructional time and the visual complexity of several batik patterns, which required additional teacher guidance. **Research Implications:** The findings indicate that the integration of cultural contexts into the RADEC learning sequence can provide a structured setting for students to connect geometric concepts with familiar cultural objects and express their mathematical understanding through design activities. For elementary mathematics teachers, the selection of accessible batik patterns, sufficient learning time, and appropriate scaffolding are important considerations in implementing this approach. **Originality:** This study contributes to qualitative research on RADEC and ethnomathematics by conceptualizing batik not merely as a cultural object for identifying mathematical elements, but as a contextual medium for students' active construction and expression of geometric understanding. The study highlights how the combination of a structured learning sequence and local cultural context can create opportunities for students to move from recognizing geometric forms toward discussing, explaining, and applying their properties through batik motif design.

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INTRODUCTION

Mathematics education at the elementary school level plays a pivotal role in shaping students' cognitive foundations, spatial reasoning, and critical and analytical thinking skills (Mahmud & Mohd Drus, 2023). Mathematics is no longer regarded merely as a discipline of mechanical computation focused on formula memorization and number manipulation, but rather as a medium for training conceptual reasoning, contextual problem-solving, and logical communication (Pramiswari et al., 2023). Among the various domains within the elementary mathematics curriculum, geometry occupies a central position because it is directly related to students' ability to visually represent and understand the spatial structure of objects in their surrounding environment (Nuraini et al., 2023). A solid understanding of geometric concepts from an early age is an essential prerequisite for students to master more complex mathematical material at subsequent levels of education (Elfauzy et al., 2026). Conceptual understanding in geometry does not merely involve the ability to recognize shapes, but also encompasses an understanding of the properties of geometric figures, the relationships between different shapes, and their application in real-world problems (An Nissa Putri et al., 2024)

However, classroom practice reveals that geometry is still widely perceived as one of the most difficult and intimidating domains for elementary school students (Sarah Fauziah Iskandar et al., 2022). Referring to Van Hiele's theory of geometric thinking development, elementary school students are positioned at the transition from the visualization stage (holistic shape recognition) toward the analysis stage (understanding the specific properties of plane figures). The primary obstacle arises when geometry instruction does not account for students' developmental stages of geometric thinking. According to Van Hiele's theory, geometric reasoning develops progressively from visual recognition of shapes to the analysis of their properties and relationships (Wibawa & Kania, 2025). Consequently, students tend to experience spatial misconceptions; they may visually recognize the names of shapes such as squares or triangles, yet falter when asked to elaborate on their conceptual characteristics, such as the relationship between parallel sides, angle measures, symmetry, and diagonal lines (Sarah Fauziah Iskandar et al., 2022). The ability to understand mathematical concepts can also be observed through students' capacity to identify relevant information and explain their understanding using their own words (Ekowati et al., 2024). Furthermore, students often have difficulty reasoning when distinguishing between pairs of visually similar plane figures, such as differentiating a parallelogram from a trapezoid or a rhombus from a kite. This condition underscores the importance of pedagogical interventions that transform geometric abstraction into a concrete, visual, and contextual learning experience.

In response to these conceptual challenges, an instructional design innovation grounded in constructivism is needed to foster active student engagement. One promising constructivist-based learning model is the Read, Answer, Discuss, Explain, and Create (RADEC) model, which consists of five sequential stages: Read, Answer, Discuss, Explain, and Create (Pratama et al., 2019). The Read and Answer stages provide students with the opportunity to independently construct initial understanding and identify aspects of the material that remain unclear. The Discuss and Explain stages cultivate social interaction skills, cognitive reasoning, and mathematical communication competence through the public clarification of ideas (Suryadi et al., 2024). Meanwhile, the Create stage serves as the culminating phase, in which students are challenged to apply the conceptual knowledge they have acquired to produce a tangible product (Fitri et al., 2023). The RADEC syntactic sequence provides structured opportunities for students to engage individually and collaboratively through reading, answering, discussing, explaining, and creating.

The RADEC model can be contextualized through local cultural resources using an ethnomathematics approach (Gusti et al., 2024). Ethnomathematics, as conceptualized by D'Ambrosio, views mathematical ideas and practices as embedded in cultural contexts and everyday activities of different cultural groups (D'Ambrosio, 1985). The integration of ethnomathematics into formal learning can serve as a cultural bridge between abstract mathematical concepts and students' lived realities, thereby supporting meaningful learning (Gusti et al., 2024). Indonesia is rich in cultural products that contain mathematical elements, including batik cloth motifs (Sudrajat et al., 2023). Traditional Indonesian batik motifs, such as Batik Ceplok, Nitik, Tambal, and Kawung, as well as batik from the Kalimantan and Pamekasan regions, contain various geometric elements, including points, lines, angles, and plane figures that can be explored in elementary geometry learning (Septiadi et al., 2023; Sudrajat et al. 2023). Using batik patterns as a medium and learning resource for elementary geometry not only supports the visualization of geometric concepts and properties of plane figures but also instills a sense of pride and awareness among students in preserving the nation's local cultural heritage from an early age (Zubaedah & Hidayah, 2023).

Previous studies have demonstrated the potential of batik-based ethnomathematics as a context for mathematics learning. Septiadi et al. (2023), for example, explored geometric concepts contained in Pamekasan batik and discussed their potential use as a context for geometry learning. Similarly, Sudrajat et al. (2023) identified geometric concepts in Kalimantan batik and proposed learning activities in which students observe, analyze, and present geometric elements found in batik motifs. Other studies have also explored batik as a potential context for elementary mathematics learning, including the identification of elementary mathematical concepts embedded in

Batik Karang motifs (Rahmawati & Rahmawati, 2023). These studies demonstrate the relevance of batik as a cultural context and learning resource, but their primary focus remains on exploring mathematical elements or developing learning resources based on particular batik motifs. In parallel, studies on the RADEC model have examined its application in mathematics learning. Fitri and Caswita (2023), for instance, explored the application of RADEC in mathematics learning with a focus on students' collaboration skills, while Ramadhani et al. (2023) examined the use of RADEC in relation to mathematics learning outcomes among fifth-grade elementary school students. These studies demonstrate that RADEC has been applied in mathematics learning to support students' collaborative learning and learning outcomes. However, they do not specifically examine the integration of batik-based ethnomathematics into the RADEC learning sequence for teaching the characteristics of plane figures to fifth-grade elementary school students.

This research gap is further contextualized by empirical findings from a preliminary study conducted in a fifth-grade elementary school classroom. The results of initial interviews and observations revealed that, although teachers had attempted to relate geometric material to concrete objects and batik motifs, students continued to experience conceptual difficulties. Students were able to recognize basic shapes such as triangles or circles in batik images, yet struggled to articulate the properties of plane figures using their own words, frequently confused rhombuses with kites, and tended to be passive, delegating group tasks to more academically capable peers. This phenomenon suggests that the presence of batik-based media alone may be insufficient without being supported by the syntax of a learning model that provides structured opportunities for students to read, discuss, explain, and create knowledge both independently and collaboratively.

To address this research gap and the aforementioned learning challenges, this study introduces an approach that integrates the ethnomathematics of Indonesian batik patterns across the syntactic stages of the RADEC model in geometry instruction for fifth-grade elementary school students. The novelty of this research lies in shifting the function of batik from an object of visual identification to a medium for exploration and active creation, wherein students not only identify plane figures within batik motifs but also articulate their properties and re-represent them in their own original batik motif designs during the Create stage. Based on this background, this study aims to: (1) provide an in-depth description of the implementation of the RADEC model integrated with batik-pattern ethnomathematics in teaching the characteristics of plane figures in a fifth-grade elementary school classroom; (2) analyze students' cognitive activity, collaborative engagement, and understanding of geometric concepts as observed across each syntactic stage of the batik-based RADEC sequence; and (3) identify the operational challenges faced by teachers and students during the learning process as a basis for pedagogical improvement recommendations.

METHOD

1. Research Design

This study employed a qualitative, descriptive-exploratory approach. This approach was selected to provide a comprehensive and in-depth description of the phenomenon of learning implementation, the dynamics of students' cognitive and collaborative activities, and the operational challenges encountered during the implementation of the Read, Answer, Discuss, Explain, and Create (RADEC) model integrated with batik-pattern ethnomathematics in geometry instruction. The descriptive qualitative design enabled the researcher to observe students' learning behaviors and interactions naturally (in a naturalistic setting) within an authentic classroom setting, without manipulating the classroom setting or instructional variables.

2. Research Subjects and Location

This study was conducted at MI Senden, Indonesia, during the first semester of the 2026/2027 academic year. The research participants consisted of one fifth-grade classroom teacher and 18 fifth-grade students. All 18 students in the class were included as participants. The classroom teacher was selected based on direct involvement in the implementation of geometry instruction, while all students participated in the learning activities and provided data through classroom observations, student work, and. The students had varying levels of academic ability.

3. Learning Procedure and Flow

The learning procedure, consisting of the five RADEC stages integrated with traditional Indonesian batik motifs, is illustrated in the following diagram.

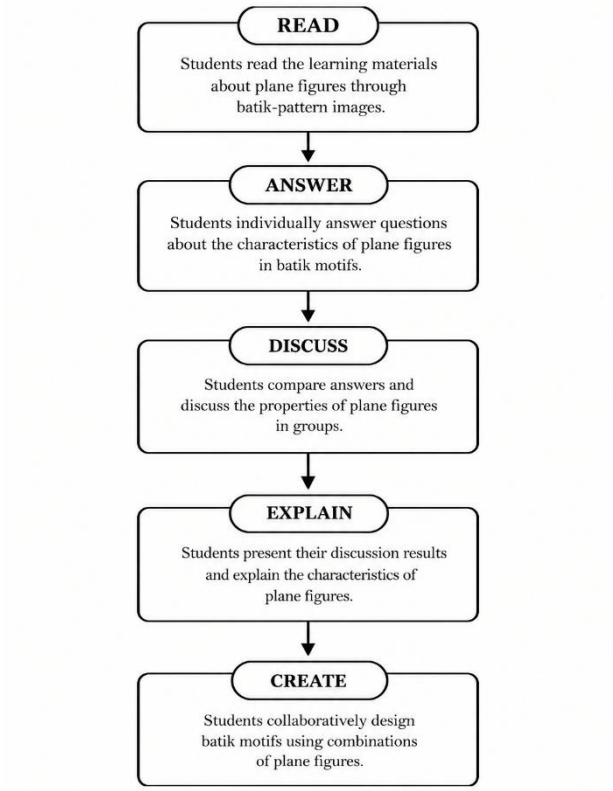

Figure 1. Learning Procedure of the RADEC Model Integrated with Batik Ethnomathematics

Data collection techniques in this study consisted of observation, interviews, and documentation. Observation was conducted to examine the implementation of each RADEC stage and students' participation during learning activities, including individual participation, group interaction, communication of geometric ideas, and the creation of batik motifs. Interviews were conducted with the fifth-grade teacher before and after the learning intervention to obtain information about initial learning conditions, students' prior understanding of plane figures, teaching practices, and the teacher's reflections on the learning process, student responses, and challenges encountered. Documentation involved examining students' worksheets to assess their understanding of geometric concepts and analyzing their batik motif designs using an assessment rubric covering the identification and properties of plane figures, comparisons of geometric characteristics, and the application of plane figures in batik motifs. Students' responses during the closing activity were also documented as supporting data on their understanding of the learning material.

4. Data Collection Techniques and Instruments

Data were collected through three techniques: interviews, observation, and documentation. Each technique used its own instrument, so the data could show the learning conditions before the lesson, how the RADEC stages were carried out, how students responded during learning, and how well they understood the material.

Semi-structured interviews were held with the fifth-grade teacher before and after the learning intervention, using an interview guide. The pre-intervention interview aimed to find out the learning conditions before RADEC was used. It asked how geometry was usually taught, how well students understood plane figures, and what difficulties they had, such as mixing up similar shapes or struggling to explain a shape in their own words. It also asked how active students were in class and in group discussions, which learning models and media the teacher used, and whether the teacher had linked lessons to daily life, local culture, and batik patterns. In addition, the teacher was asked how students responded to learning activities and what the class needed. The post-intervention interview aimed to collect the teacher's reflections after the lesson. It asked how the RADEC model worked in the classroom, how students responded in each stage (Read, Answer, Discuss, Explain, and Create), and whether their understanding of plane figures had changed. It also asked whether students could find plane figures in batik patterns and connect mathematics with culture, how well they worked together, what problems came up, what the strengths of the model were, whether it suited fifth-grade students, and what should be improved.

Observation was done during the lesson using an observation sheet. The sheet had two parts. The first part checked whether each RADEC stage was carried out as planned in the teaching module. The second part recorded how students took part in each stage. In the Read stage, it noted whether students read on their own and marked

important information. In the Answer stage, it noted whether they completed the individual worksheet independently. In the Discuss stage, it noted how students shared ideas and worked together in their groups. In the Explain stage, it noted whether students could communicate and explain geometric ideas to others. In the Create stage, it noted how they took part in designing the batik motif. Besides the observation sheet, observation also looked at the results of the learning process by checking all of the student worksheets (LKPD) with the assessment rubric from the teaching module. The individual worksheet in the Answer stage contained fill-in questions about the properties of plane figures, and each answer was marked correct or incorrect. The group worksheet in the Discuss stage had two activities. In the first activity, students identified the properties of each plane figure in tables, and answers that were correct and complete received the highest score, partly correct answers received a middle score, and wrong or empty answers received no score. In the second activity, students compared the characteristics of different plane figures, and their answers were scored by how correct, complete, and clear they were. The project worksheet in the Create stage asked each group to design a batik motif based on an assigned pattern (Ceplok, Nitik, Tambal, or Kawung) and to fill in a table listing the plane figures they used and their properties. The design was assessed on how well it matched the batik pattern, how plane figures were used, creativity, neatness, and how accurately the table was filled in, with each aspect given equal weight. A group's final worksheet score was the average of its scores on the three parts, and every member received the group's score. To see students' responses during learning, attitude and skill rubrics from the teaching module were also used. The attitude rubric looked at faith and good character, critical reasoning, cooperation (*gotong royong*), and independence. The skill rubric looked at how students asked questions, answered questions, and presented their work. Each aspect was rated from very good to needing guidance. In the closing activity, the teacher also asked students what they had learned, which plane figure was easiest to understand, and what benefit they gained from learning through batik. Their answers were recorded as additional evidence of their understanding.

Documentation took the form of photographs taken by the researcher during the lesson. The photographs captured students' activities in each RADEC stage: reading the instructional materials (Read), completing the individual worksheet (Answer), comparing answers in group discussions (Discuss), presenting group results (Explain), and designing batik motifs (Create). Photographs were also taken of students' responses on the LKPD and of the PowerPoint slide used to identify plane figures in batik patterns. In addition, each group's batik design, which was the product of the group's collaborative work, was photographed. These photographs supported the observation notes by showing what students were doing at each stage, and they were interpreted together with the observation and interview data rather than as stand-alone evidence. The researcher also maintained systematic records of observation notes, teacher interview data, students' responses, student worksheets, and batik design documentation to support the transparency and consistency of the data analysis.

5. Data Analysis Technique and Trustworthiness

Data analysis was conducted systematically using the interactive model of Miles, Huberman, and Saldaña's (2014), which comprises three concurrent stages: data condensation, data display, and conclusion drawing and verification. Before data condensation, the researcher organized and coded the data obtained from classroom observations, teacher interviews, students' responses during the closing activity, student worksheets, and batik design products. Initial codes were developed based on the research objectives and the RADEC stages, including students' understanding of plane figures, individual participation, group interaction, mathematical communication, batik motif creation, and learning challenges. Related codes were then grouped into broader categories representing the implementation of the RADEC stages, students' learning activities and understanding, and challenges encountered during the learning process. Data condensation involved selecting, simplifying, focusing, and transforming the raw data from field observation notes, interview data, and documentation of student work, while excluding information that was irrelevant to the research objectives. Data display involved presenting the condensed data in systematic descriptive narratives and summary tables, supported by relevant visual documentation of classroom activities and student work to facilitate the interpretation of the findings. Conclusion drawing and verification involved identifying patterns and relationships among the RADEC stages, students' learning activities, geometric understanding, and challenges encountered during the learning process.

To ensure the trustworthiness of the data throughout these analysis stages, this study applied technique triangulation and source triangulation. Technique triangulation was conducted by comparing data obtained through classroom observations, teacher interviews, students' responses during the closing activity, student worksheets, and batik design products. The researcher compared these sources to examine the consistency of information regarding the implementation of the RADEC stages, students' engagement and understanding of plane figures, and the challenges encountered during the learning process. Source triangulation was conducted by comparing information obtained from the fifth-grade teacher with observations of students' learning activities and evidence from students' worksheets and batik design products. As a result, the emerging interpretations were continuously checked against the available observation, interview, student response, worksheet, and artifact data to ensure that the conclusions were grounded in the collected evidence and consistent with the triangulated data. The researcher

also maintained systematic records of observation findings, interview responses, student work, and analytical decisions throughout the research process to support the transparency and consistency of the interpretation.

RESULTS

1. Initial Conditions of Geometry Learning

Preliminary findings were obtained through observations of mathematics instruction and interviews with the fifth-grade classroom teacher. The observation results indicated that geometry instruction had been conducted by relating the concept of plane figures to concrete objects and elements of students' surrounding environment. The teacher used classroom objects, images, worksheets, and occasionally animated videos to help students recognize the shapes and properties of plane figures. Instruction had also been linked to cultural context through examples of batik and woven-fabric motifs. Although students were generally familiar with basic shapes, their understanding became less consistent when they were required to explain geometric properties. As the teacher explained:

"Students already know basic shapes such as triangles, squares, and circles. However, when they are asked about their properties, many of them are still confused, for example, when identifying the two pairs of parallel sides of a rectangle and distinguishing it from a square." (Pre-intervention teacher interview)

The teacher further identified three main difficulties: remembering the characteristics of different plane figures, explaining those characteristics using their own words, and distinguishing between similar shapes. In particular, students frequently confused rhombuses with kites and had difficulty distinguishing between trapezoids and parallelograms. The teacher also explained that students were often able to point to a geometric feature but had difficulty explaining it in their own words. These observations were consistent with the teacher's report that students could recognize familiar shapes but experienced difficulties when asked to describe, compare, or explain their properties.

The initial learning activities also revealed variation in students' participation. Some students were responsive when the teacher asked direct questions, whereas others remained passive and required teacher guidance. This pattern was particularly evident during group activities. The teacher reported:

"Students generally participated in group activities, although two or three students tended to dominate the discussion while some others remained quiet and waited for their peers to complete the task." (Pre-intervention teacher interview)

The teacher also noted that students were still hesitant to explain their work in front of the class and generally needed to be selected and supported before they were willing to speak. These findings describe initial learning conditions characterized by difficulties in understanding the properties of plane figures, as well as variation in students' participation, mathematical communication, and involvement in collaborative activities.

The teacher had previously introduced batik and woven-fabric motifs as cultural contexts for geometry learning. The teacher reported that students had previously been asked to identify and circle geometric shapes, such as triangles, squares, and rhombuses, within Batik Ceplok patterns. However, the preliminary findings showed that the use of batik was primarily oriented toward recognizing geometric shapes within existing motifs.

Table 1. Initial Conditions of Geometry Learning

Aspect Observed	Observation Result
Geometry instruction	The teacher used concrete objects, images, worksheets, and videos to support learning in geometry.
Understanding of plane figures	Students were generally able to recognize basic plane figure shapes.
Understanding of the properties of plane figures	Students still experienced difficulty explaining characteristics based on sides, angles, diagonals, and parallel sides.
Differentiating plane figures	Students still experienced difficulty differentiating figures with similar characteristics.
Student activity	Student engagement was uneven; some students still required teacher guidance.
Interaction and collaboration	During group activities, some students tended to dominate the interaction, while others were less involved in completing group tasks.
Contextual learning	The teacher related geometric concepts to objects and the surrounding environment.
Ethnomathematics	The teacher had introduced mathematical elements through woven fabric and batik motifs.
Batik patterns	The Batik Ceplok motif had previously been used to identify plane figure shapes.
Learning model	The teacher employed Problem-Based Learning (PBL) and Discovery Learning, supported by real objects and images.

Based on these preliminary findings, geometry instruction requires activities that provide students with opportunities to read and comprehend information, independently process their understanding, engage in discussion, explain concepts, and apply them in contextual activities. Therefore, the RADEC model was implemented by integrating batik patterns as an ethnomathematics context within geometry instruction.

2. Implementation of the RADEC Model in Geometry Learning

The RADEC model was implemented through five stages: Read, Answer, Discuss, Explain, and Create. Each stage provided opportunities for students to engage with the characteristics and properties of plane figures, while batik patterns served as a cultural context for identifying, explaining, and applying geometric concepts. The findings were derived primarily from classroom observations and supported by students' worksheets, classroom responses, and documentation of learning activities.

Students' geometry understanding was examined through their ability to identify plane figures, describe their properties, justify geometric classifications, communicate mathematical ideas, and apply geometric concepts in designing batik motifs. Previous research has examined mathematical conceptual understanding through RADEC and identified geometric concepts in batik patterns that can be connected to school mathematics (Nugraha & Prabawanto, 2021);Prahmana & D'Ambrosio, 2020). The present study brings these two areas together by examining students' learning processes during the implementation of RADEC integrated with batik ethnomathematics.

Read Stage

During the Read stage, students individually read instructional materials concerning the characteristics and properties of plane figures. Several students identified important information, particularly information about parallel sides and right angles. Some students also marked or highlighted information they considered important. Classroom observations showed that some students could read the materials independently, whereas others required teacher guidance to understand particular geometric terms and concepts. The students' worksheets also showed their initial responses to the reading materials, as presented in Figure 2.

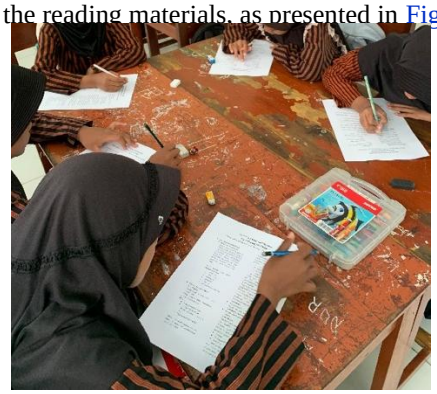

Figure 2. Students' Activities During the Read Stage

These findings indicate that students were beginning to recognize information about the properties of plane figures. However, identifying or highlighting information did not necessarily mean that students fully understood the relationships between geometric properties or could distinguish figures with similar characteristics. Their understanding at this stage was primarily reflected in their initial recognition of geometric information, which required further examination through their written answers and subsequent learning activities.

The importance of developing students' understanding of geometric concepts is consistent with Nugraha and Prabawanto (2021), who investigated mathematical conceptual understanding through the RADEC model among fourth-grade elementary school students. Their study focused on perimeter and area and reported better conceptual understanding among students who learned through RADEC than among those who received direct instruction. Although their research examined different mathematical content and used a quasi-experimental design, the present study provides complementary evidence by examining students' initial engagement with geometric information during the Read stage. In particular, the findings show that students' initial recognition of geometric properties should be distinguished from their ability to explain and apply those properties.

Answer Stage

In the Answer stage, students individually completed the Lembar Kerja Peserta Didik (LKPD) based on the information they had read. Their written responses showed that they attempted to identify the characteristics of plane figures using the information provided in the learning materials. For example, one student wrote:

"I saw in the reading that a rectangle has two pairs of sides that are the same length and parallel."

This response indicates that the student could identify and describe some properties of a rectangle. The response also suggests that the student was beginning to understand geometric figures through their attributes rather than relying solely on visual appearance. However, further evidence was needed to determine whether the student could explain other properties of a rectangle or distinguish it from a square.

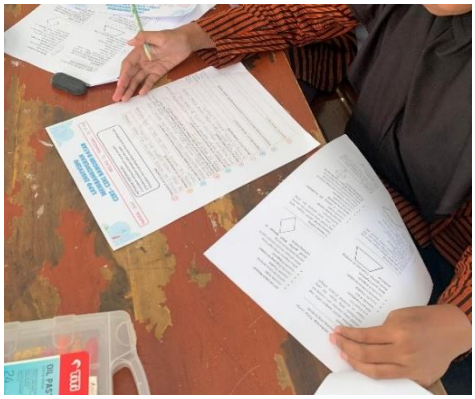

Figure 3. Students' Activities During the Answer Stage

During the activity, some students completed the questions independently, whereas others sought clarification from the teacher when they encountered difficulties. The teacher primarily directed students to reread the relevant information rather than directly providing the answers. These findings suggest that students' understanding of geometry at this stage was reflected in their ability to retrieve, interpret, and express information about plane-figure properties. However, differences in the assistance required indicated that students did not demonstrate the same level of independence in interpreting geometric concepts.

This finding can be discussed in relation to Nugraha and Prabawanto (2021), whose study highlighted the relevance of RADEC for developing students' mathematical conceptual understanding. Their results provide a basis for considering conceptual understanding as an important aspect of mathematics learning through RADEC. In the present study, the individual written responses offer more specific evidence of how students interpreted and expressed the properties of plane figures. Unlike a study focused on comparing learning outcomes, this qualitative investigation also considers the difficulties students encountered and the extent to which they could complete the tasks independently.

Discuss Stage

During the Discuss stage, students worked in groups to compare their individual answers and determine the responses they considered most appropriate. Students began expressing their opinions and providing reasons based on the characteristics of plane figures. For example, when discussing the characteristics of a plane figure, one student stated:

"I think it's a square, because all the sides are the same length and the angles are right angles."

This response indicates that the student could justify the classification of a square by referring to its defining properties, namely four equal sides and four right angles. This demonstrates understanding beyond visual recognition because the student used geometric attributes to support the answer.



Figure 4. Students' Group Discussion During the Discuss Stage

Classroom observations showed that students interacted by comparing their answers, asking questions, and discussing differences in their responses. However, participation was not fully balanced, as some students tended to dominate the discussion while others remained less involved in completing the group tasks. These findings indicate that some students were able to use geometric properties to justify their classifications. Nevertheless, the uneven participation suggests that this understanding was not demonstrated equally by all students. The responses of more active group members could not automatically be considered evidence of the understanding of every student. The Discuss stage therefore provided opportunities for students to clarify their understanding of geometric properties, although individual differences remained evident.

The use of cultural contexts to make geometric concepts more meaningful is supported by Prahmana and D'Ambrosio (2020), who explored geometric transformations and cultural values in Yogyakarta batik patterns. Their study demonstrated that batik can be examined as a source of mathematical concepts connected to cultural practices. Similarly, Sudrajat et al. (2023) identified geometric concepts in Kalimantan batik and discussed possible learning activities for elementary school students, including observing motifs, analyzing their shapes, and presenting findings. These studies support the relevance of batik as a contextual resource for geometry learning. The present study extends this context by examining how students discussed and justified geometric classifications during the RADEC learning process, although the quality of their reasoning varied across students.

Explain Stage

During the Explain stage, one representative from each group presented the results of the group discussion to the class. One student representative explained the characteristics of the plane figures identified by the group, stating:

"A square has four sides of equal length and four right angles. In this batik pattern, we find a square shape used as part of the motif."

This response indicates that the student could explain the properties of a square and relate the geometric concept to a shape found in a batik pattern. The explanation suggests that the student was beginning to connect abstract geometric concepts with familiar cultural objects.



Figure 5. Students' Presentation During the Explain Stage

Classroom observations showed that students could communicate several characteristics of plane figures based on their group discussions. Students also began relating the geometric shapes they had discussed to the batik patterns used in the learning activities. However, participation in presenting the results was not evenly distributed. Some students remained hesitant to speak in front of the class and required encouragement from the teacher.

These findings indicate that some students demonstrated their understanding by explaining geometric properties and identifying their representation in batik motifs. However, students who did not present their ideas provided less direct evidence of their individual understanding. Therefore, the findings suggest differences in students' ability to communicate geometric concepts, particularly in explaining the properties of plane figures and connecting them to real-world representations.

The findings are related to the learning possibilities discussed by Sudrajat et al. (2023), whose study proposed observing batik motifs, analyzing the geometric shapes they contain, and presenting the results as possible learning activities. In the present study, students also identified shapes in batik motifs and communicated their understanding through group presentations. However, the findings reveal an additional classroom dimension: students differed in their willingness and ability to explain mathematical ideas publicly. Thus, the present study not only considers the potential of batik as a learning resource but also examines how students communicate their understanding when batik is incorporated into the RADEC process.

Create Stage

During the Create stage, students applied the geometric concepts they had discussed by designing their own batik motifs using combinations of plane figures. Students first identified the shapes they wanted to incorporate into their designs and then divided tasks within their groups, such as drawing, coloring, and preparing the final design. The students' creative products showed the incorporation of several plane figures into their batik motif designs. For example, Group 2 incorporated squares, triangles, and circles into its batik motif. During the activity, one student commented:

"We chose square and triangular shapes to create batik motifs because these shapes are easy to combine."

This response suggests that the student could select geometric shapes and consider their use in creating a design. The students' products also provided observable evidence of their ability to represent plane figures in a new composition.



Figure 6. Students' Activities During the Create Stage

Classroom observations further showed that students were actively involved in drawing, coloring, discussing design choices, and completing their group products. Group members divided responsibilities, with some students drawing, others coloring, and others discussing and preparing the final design. These findings indicate that students could apply geometric representations in a creative activity involving batik motifs. However, the presence of recognizable geometric shapes in the finished products did not necessarily demonstrate a complete understanding of their properties. Students' explanations and design choices provided additional evidence for interpreting their understanding. Overall, the Create stage showed that some students could apply geometric concepts in a cultural context, although the depth of their understanding required consideration of both their products and their individual explanations.

This finding is consistent with research exploring the mathematical potential of batik motifs. Prahmana and D'Ambrosio (2020) identified geometric transformations within Yogyakarta batik patterns, while Abdullah and Rahmawati (2021) explored geometric concepts in Krebet wooden batik. In addition, Sudrajat et al. (2023) identified plane figures and other mathematical concepts in Kalimantan batik that could be connected to elementary geometry learning. These studies establish the relevance of batik as a source of mathematical representations. The present study differs by incorporating batik motif design into the Create stage of RADEC and examining the resulting student products alongside their explanations. Consequently, the products provide evidence of students' attempts to apply geometric concepts, while their explanations help clarify the extent to which those representations reflect their understanding.

Table 2. Observation Results of RADEC Model Implementation

RADEC Stage	Student Activity	Observation Results
Read	Reading instructional materials and identifying key information about plane figures.	Some students identified information about equal sides, parallel sides, and right angles, while others required teacher guidance. These findings indicate that students were beginning to recognize geometric properties, although their ability to explain and distinguish between figures remained to be examined.
Answer	Completing the LKPD individually based on the reading materials.	Students attempted to describe plane-figure properties in writing. Some worked independently, while others required clarification. Their responses provided evidence of their ability to identify and express geometric properties, although their

		understanding of relationships between figures was not yet fully established.
Discuss	Comparing answers, expressing opinions, and justifying geometric classifications.	Some students justified their answers by referring to equal sides and right angles. However, participation was uneven. These findings indicate that some students could use geometric properties to justify classifications, while individual differences in understanding and participation remained evident.
Explain	Presenting group discussion results and explaining plane-figure properties in relation to batik motifs.	Some students explained the properties of plane figures and identified corresponding shapes in batik patterns. Others were hesitant to present. The findings indicate that some students could communicate geometric properties and connect them with cultural representations, although this ability was not demonstrated equally by all students.
Create	Designing batik motifs using combinations of plane figures.	Students incorporated squares, triangles, circles, and other shapes into their designs and divided responsibilities within their groups. Their products demonstrated the application of geometric representations, while their explanations helped indicate the reasoning behind their design choices. However, the products alone did not establish complete understanding of geometric properties.

3. Understanding Geometry through Batik Patterns and Student Learning Products

The use of batik patterns in the learning activities provided students with opportunities to identify plane figures and examine their characteristics in a cultural context. Students observed Batik Ceplok, Nitik, Tambal, and Kawung patterns and identified geometric shapes embedded within the motifs. These activities were designed to help students connect the properties of plane figures introduced in the learning materials with geometric forms found in familiar cultural objects.

Students' geometry understanding was examined through their written responses, observations of their learning activities, explanations reported by the teacher, and batik motif designs. The analysis focused on students' ability to recognize plane figures, describe their properties, distinguish between geometric shapes, and apply these shapes in their own designs. These aspects provided a basis for interpreting the evidence of geometry understanding demonstrated throughout the learning activities.

Students' LKPD responses provided evidence of their attempts to identify and describe the characteristics of plane figures, including their sides, angles, and other geometric properties. As shown in Figure 7, students recorded their responses in the provided table. Completing this activity required students to associate each plane figure with its corresponding characteristics. Their written responses therefore provided evidence of their ability to express geometric information rather than merely recognize shapes visually. However, the accuracy and completeness of these responses needed to be considered when interpreting the extent of their understanding.

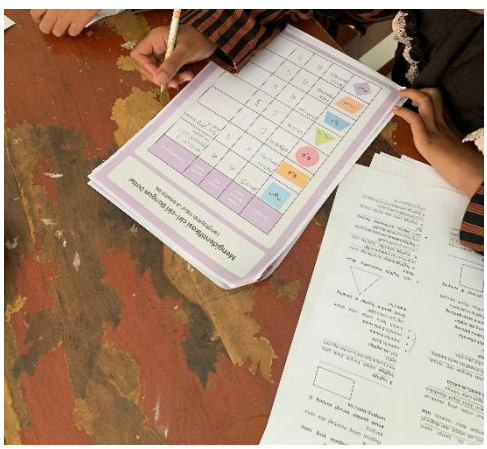

Figure 7. Students' Responses in the LKPD

The instructional PPT subsequently presented examples of batik patterns and directed students to identify the plane figures contained within the motifs. This activity provided opportunities for students to recognize geometric forms in cultural representations and connect them with the properties discussed in the learning materials. In terms of geometry understanding, identifying shapes in batik patterns indicated students' ability to recognize geometric forms in a contextual setting. Nevertheless, visual recognition alone did not establish whether students could explain the defining properties of the identified shapes.



Figure 8. PPT Activity for Identifying Plane Figures in Batik Patterns

The teacher's post-intervention interview provided further insight into students' responses during this activity. The teacher reported that students were able to identify geometric shapes in batik patterns and recalled one student's statement:

"Ma'am, the Kawung batik contains circles that are cut into pieces, making them look like squares."

(Post-intervention teacher interview). This response illustrates the student's attempt to interpret the geometric forms in the Kawung motif by comparing their visual appearance with familiar shapes. The student's reference to circles indicates an ability to recognize circular forms, while the comparison with squares suggests an attempt to relate the observed shapes to previously learned geometric concepts. However, the statement alone does not establish whether the student could distinguish the defining properties of circles and squares. It therefore provides evidence of visual recognition and comparison, while the student's understanding of the properties of each shape would require further examination. The teacher further reported that students were able to connect mathematical concepts with cultural contexts, explaining:

"They can make connections. They realize that mathematics is not far from culture."

(Post-intervention teacher interview). This statement reflects the teacher's perception that students were beginning to connect mathematical concepts with cultural objects. When considered alongside the students' identification activities, the interview suggests that batik patterns provided a context for recognizing and discussing geometric forms. However, the teacher's perception was interpreted alongside the other research evidence rather than treated as conclusive proof of every student's geometry understanding.

The geometric concepts explored through the batik patterns were subsequently applied during the Create stage. Students designed their own batik motifs using combinations of plane figures. They discussed the shapes they wanted to incorporate and divided responsibilities within their groups, including drawing, coloring, and preparing the final products.



Figure 9. Students' Batik Motif Designs

The students' designs showed their attempts to represent and combine plane figures in their own visual compositions. The use of recognizable geometric shapes provided evidence of their ability to apply geometric representations in a creative task. Furthermore, discussions about design choices offered opportunities for students to explain how the selected shapes could be combined. Such explanations were important for interpreting whether students' design choices reflected an understanding of geometric concepts rather than visual imitation alone. The teacher's post-intervention interview further indicated that the Create activity generated strong student engagement. The teacher stated:

"When they were asked to create batik motif designs using plane figures, they were very enthusiastic. They were proud of their work."

(Post-intervention teacher interview). This finding was consistent with classroom observations, which showed students actively drawing, coloring, discussing design choices, and completing their group products. In relation to geometry understanding, these activities provided opportunities for students to apply their knowledge by selecting, combining, and representing plane figures in their batik designs. Their design choices and discussions offered evidence of how they used geometric forms in a visual context. Nevertheless, enthusiasm and active participation alone did not demonstrate a complete understanding of the properties of each shape. The students' products and explanations therefore needed to be considered together when interpreting their understanding.

Taken together, the LKPD responses, classroom observations, instructional PPT activities, teacher interview, and students' batik motif products provided complementary evidence of students' geometry understanding. The written responses showed students' attempts to identify and describe the properties of plane figures, while the batik identification activities provided evidence of their ability to recognize and compare geometric forms in cultural patterns. The teacher's account offered additional insight into students' connections between mathematics and culture, while their batik designs demonstrated their attempts to apply plane figures in their own visual compositions.

These findings also illustrate how the RADEC stages provided different opportunities for students to engage with geometric concepts. The Read and Answer stages supported students in accessing and expressing information about plane-figure properties. The Discuss and Explain stages provided opportunities to compare geometric classifications, justify answers, and communicate mathematical ideas. The Create stage allowed students to apply geometric representations through batik motif design. However, the evidence did not indicate that all students demonstrated the same level of understanding at every stage. Students' geometry understanding was therefore interpreted through their written responses, explanations, and learning products rather than their participation or enthusiasm alone.

4. Challenges in Implementing the RADEC Model

The implementation of the RADEC model integrated with batik patterns revealed several challenges during the learning process. Classroom observations showed that the five RADEC stages required considerable time, particularly during the Discuss, Explain, and Create stages. Students needed time to compare their answers, present their group findings, and complete their batik motif designs. This observation was consistent with the teacher's post-intervention interview, in which the teacher identified time management as one of the challenges encountered during the implementation of the five RADEC stages.

Classroom observations also showed that some students experienced difficulty identifying plane figures within batik patterns, particularly when the patterns contained relatively complex arrangements. In such situations, some students required teacher guidance to identify the geometric shapes represented in the motifs. The teacher similarly reported that several students still had difficulty identifying plane figures in complex batik patterns and suggested using simpler patterns that were more appropriate for fifth-grade students.

The Explain stage revealed another challenge related to students' participation in classroom presentations. Classroom observations showed that some students were hesitant to present their group discussion results and required encouragement from the teacher before speaking in front of the class. This finding was also reflected in the teacher's post-intervention interview, in which the teacher explained that the students who presented were often the same students, while other students still needed encouragement and appreciation to participate in the presentation.

Variation in group participation was also observed during the Discuss and Create stages. Some students were actively involved in completing group tasks, whereas others participated less actively. The teacher reported that students had begun to divide responsibilities, such as drawing, coloring, and preparing presentations, although participation among group members was not always evenly distributed.

Based on the classroom observations and the teacher's post-intervention interview, several considerations emerged for future implementation. The teacher suggested improving time management, simplifying the LKPD, and selecting batik patterns with less complex visual arrangements. These considerations reflect the practical

challenges observed during the implementation while maintaining the integration of batik ethnomathematics within the RADEC learning sequence.

DISCUSSION

The research findings indicated that, under the initial conditions, students were already able to recognize several basic plane figures but still experienced difficulties in explaining their properties and distinguishing between figures with similar characteristics (De León-Zamora et al., 2023; Triyono et al., 2024). These findings suggest that geometry instruction at the elementary school level should not be limited to guiding students in recognizing the names and shapes of figures, but should also provide opportunities to identify characteristics, compare properties, and communicate understanding of geometric concepts (Nurussama et al., 2025). Using contexts closely related to students' experiences can make abstract geometric concepts more meaningful during learning (Dewi et al., 2026). Research on ethnomathematics has likewise demonstrated that geometric concepts can be found within various cultural contexts and utilized as a source of mathematics learning in elementary schools (Sudrajat et al., 2023).

The implementation of the RADEC model provided a structured sequence that addressed these initial learning needs. During the Read and Answer stages, students worked individually with the learning materials and LKPD to develop an initial understanding of plane-figure characteristics. The Discuss stage then allowed students to compare their answers and express their reasoning, while the Explain stage provided an opportunity to communicate their understanding to the class. The Create stage extended this process by asking students to apply the geometric concepts in batik motif designs. In this study, the sequence was relevant to the students' initial learning needs because each stage provided a different opportunity to engage with geometric concepts. Students first accessed information through reading, formulated individual responses, compared their understanding through discussion, communicated their reasoning, and finally applied the concepts by identifying and incorporating plane figures into batik motif designs. Thus, the five RADEC stages were connected sequentially, with students moving from accessing information and formulating individual responses toward discussing, explaining, and applying geometric concepts. This sequence is in line with the intended structure of RADEC, which emphasizes reading, answering, discussing, explaining, and creating as interconnected forms of active learning (Sakristi & Relmasira, 2025; Rifa Pratiwi & Yullys Helsa, 2025). Previous research has also reported the potential of RADEC to support communication and higher-order thinking through active student engagement (Rifa Pratiwi & Yullys Helsa, 2025).

The Discuss stage further illustrated how the RADEC sequence supported opportunities for students' mathematical communication. Students compared their individual answers, asked questions, and provided justifications based on the characteristics of plane figures. Although group member involvement was not fully balanced, classroom observations showed that students exchanged ideas and clarified differences in their responses. This pattern suggests that the discussion stage created opportunities for students to construct and communicate their geometric understanding through interaction with peers, while differences in participation remained a condition that required teacher support. This finding is consistent with Suryadi et al. (2024), who reported that providing opportunities for fifth-grade students to discuss and articulate their mathematical thinking through RADEC can support the development of mathematical communication skills.

The integration of batik ethnomathematics became particularly evident during the Explain and Create stages, when students were required to relate geometric characteristics to visual forms found in batik patterns. During the Explain stage, students presented the results of their group discussions and described the characteristics of the plane figures they had identified. The classroom observations showed that students began referring to the shapes appearing in Batik Ceplok, Nitik, Tambal, and Kawung patterns when explaining their geometric understanding. This indicates that the batik context was not used merely as an illustration, but provided a concrete visual reference through which students could articulate geometric concepts.

The integration became more apparent during the Create stage. Students applied the geometric concepts they had discussed by incorporating plane figures into their own batik motif designs. The activity required students to move beyond identifying shapes in existing motifs and use those shapes as elements of a new visual representation. Classroom observations showed students discussing which plane figures to include, dividing responsibilities for drawing and coloring, and completing their group designs. The teacher's post-intervention interview also indicated that students showed strong enthusiasm during this activity and were proud of their completed designs. These findings suggest that the Create stage provided a condition in which geometric understanding was connected with cultural representation through an active process of designing.

Taken together, the findings suggest that the integration of batik ethnomathematics operated through a gradual process across the RADEC stages. The Read and Answer stages provided students with geometric information and opportunities to formulate individual responses. The Discuss and Explain stages enabled students to compare, justify, and communicate their understanding. The batik patterns then provided a visual and cultural

context for applying these concepts, particularly during the Explain and Create stages. Through this sequence, students moved from learning the characteristics of plane figures to identifying those figures in cultural patterns and subsequently incorporating them into their own designs. Thus, the contribution of the batik context in this study was not simply to make the lesson culturally relevant, but to provide a concrete representation through which geometric concepts could be identified, discussed, explained, and applied.

A prominent finding in this study emerged during the Create stage. Students displayed enthusiasm when asked to design batik motifs using various plane figure shapes. During this stage, students began applying the concepts they had learned through activities such as drawing, arranging patterns, coloring, and dividing tasks within their groups. This indicates that the Create activity enabled students to apply geometric concepts through tangible products. This finding is consistent with research on the development of RADEC-based teaching materials for fifth-grade students, which demonstrated that RADEC can be directed toward the development of higher-order thinking skills through learning activities that actively engage students (Fitri et al., 2023). Other research has also shown that RADEC can support 4C skills, including students' creativity and collaboration (Sukmawati et al., 2024).

The integration of batik patterns provided a cultural context within the geometry learning process. In this study, students identified plane figures within the Batik Ceplok, Nitik, Tambal, and Kawung patterns before using these shapes to create their designs. This finding indicates that batik patterns can serve as concrete objects to connect geometric concepts with culture. This is reinforced by Sudrajat et al. (2023), who identified various geometric concepts such as rectangles, circles, triangles, points, lines, and transformations within several Kalimantan batik motifs, which hold potential for use in elementary school geometry instruction.

This finding is also consistent with research by Danar Septiadi et al. (2023), who identified various geometric concepts in Pamekasan batik motifs and demonstrated their potential as a context for geometry instruction. That study revealed that exploring batik can help connect mathematical concepts with Indonesian culture. Thus, the use of batik patterns in this study is grounded in empirical evidence that cultural products can provide a context for presenting geometric concepts in mathematics instruction.

The use of batik in this study did not stop merely at identifying plane figures. Students subsequently used these shapes to produce batik motif designs. This constitutes an important distinction from prior ethnomathematics research, which has tended to focus on exploring mathematical elements within cultural motifs. Studies by Sudrajat et al. (2023) and Danar Septiadi et al. (2023) demonstrate that such learning has centered on identifying the geometric concepts embedded within batik motifs and their potential as a learning context. This study extends that utilization by situating batik patterns within the sequence of RADEC activities, such that students not only identify geometric concepts but also discuss, explain, and apply them to create original products.

This integration of ethnomathematics also demonstrates that mathematics education can connect school-based knowledge with the culture present in students' own environments. Research on the distinctive Karang batik of Tuban identified concepts such as points, lines, angles, plane figures, fold symmetry, and geometric transformation that can be utilized in elementary school mathematics instruction. That study also showed that a batik-based context can help students recognize and preserve the culture in their surrounding environment (Rahmawati & Rahmawati et al., 2023).

The findings of this study further indicate that students began to understand the relationship between mathematics and culture. This was evident in students' ability to identify plane figures within batik patterns and connect them to the material they had learned. This finding is consistent with research by Putri et al. (2025), who developed an ethnomathematics module using the Nagori Kuansing batik motif for geometry instruction. That study demonstrated that integrating batik motifs into learning can help connect plane geometry concepts to a cultural context meaningful to students.

The novelty of this study lies in integrating the RADEC model with batik-pattern-based ethnomathematics into elementary school geometry instruction. Prior research on batik and ethnomathematics has extensively demonstrated the presence of geometric concepts within various batik motifs (Sudrajat et al., 2023; Danar Septiadi et al., 2023) Meanwhile, research on RADEC has shown that the Read, Answer, Discuss, Explain, and Create stages can be used to promote student engagement in the learning process and to develop thinking and communication skills (Putri et al., 2025; Suryadi et al., 2024) This study combines both approaches within a single instructional sequence, such that batik patterns function not merely as objects for identifying geometric concepts, but as a context employed throughout the processes of reading, answering, discussing, explaining, and creating.

From an instructional practice perspective, the research findings indicate that the RADEC model, integrated with batik patterns, can provide a more diverse learning experience. Students were allowed to learn independently during the Read and Answer stages, interact during the Discuss stage, communicate their understanding during the Explain stage, and apply concepts through tangible products during the Create stage. The integration of cultural context also enabled geometric concepts to be learned not merely as shapes and properties to be memorized, but as elements that can be observed and used to produce a work of art. Findings from research on RADEC-based

mathematics learning and batik ethnomathematics research support the use of both approaches as alternatives for delivering more active and contextual mathematics instruction (Prastiwi et al., 2026; Putri et al., 2025).

Nevertheless, this study identified several challenges in its implementation. The five RADEC stages required considerable time management, while the Create activity took additional time to draw and complete the designs. In addition, some students experienced difficulty identifying plane figures within overly complex batik patterns. This finding indicates that the application of ethnomathematics needs to take into account the level of difficulty of the cultural context employed. Batik patterns used as a learning resource should be tailored to students' abilities so that the cultural context continues to support conceptual understanding, rather than adding difficulty to the identification process. Research on the development of ethnomathematics-based worksheets using batik motifs has likewise demonstrated the importance of aligning instructional materials with the needs and characteristics of elementary school students.

Overall, this study demonstrates that the RADEC model integrated with batik patterns can serve as an alternative approach to geometry instruction that combines conceptual understanding, communication, collaboration, creativity, and cultural context. These findings should not be interpreted as statistical evidence of improved learning outcomes, but rather as qualitative findings concerning changes in student activity and engagement throughout the learning process. Accordingly, this research on instructional practice suggests that teachers can use cultural patterns as a context for geometry instruction while remaining attentive to the structure of learning stages, time management, pattern complexity, and students' needs.

CONCLUSION

This qualitative descriptive study examined the implementation of the RADEC model integrated with batik-based ethnomathematics in fifth-grade geometry learning. The findings indicate that students initially recognized several basic plane figures but experienced difficulties in explaining their characteristics and distinguishing between similar figures. Through the RADEC sequence, students engaged in reading, answering, discussing, explaining, and creating activities, with batik patterns providing a cultural and visual context for identifying and applying geometric concepts.

The integration of batik ethnomathematics was observed particularly when students identified plane figures in Batik Ceplok, Nitik, Tambal, and Kawung patterns and incorporated these figures into their own motif designs. These findings represent a context-specific qualitative description of students' activities and engagement rather than evidence of statistically measured learning improvement. The study's contribution lies in integrating batik patterns throughout the RADEC sequence, from identifying geometric concepts to applying them in students' own designs.

The study was limited to one school and 18 fifth-grade students, with findings derived from classroom observations, teacher interviews, students' worksheets, and learning products. No quantitative assessment was conducted to measure changes in learning outcomes. Practical challenges included limited instructional time and the complexity of some batik patterns. Therefore, implementation should consider appropriate time allocation, worksheets, and pattern complexity. Future research may examine RADEC integrated with other cultural contexts or geometric topics across broader learning settings.

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AUTHOR CONTRIBUTION STATEMENT

IM conceptualized the research design, conducted fieldwork and data collection, performed data condensation and analysis, and drafted the original manuscript. BS provided supervision, validated the methodology and data analysis, reviewed and edited the manuscript, and approved the final version

AI DISCLOSURE STATEMENT

The authors used Gemini during the preparation of this work for language editing and grammar checking. After using the tool/service, the authors thoroughly reviewed and edited the content as needed and take full responsibility for the content of the publication.

Ikrima Romadhona Maqhfiroh
Department of Elementary Teacher Education, Faculty of Education, Science, and Humanities,
Universitas Muhammadiyah Malang,
Jl. Raya Tlogomas No. 246, Malang, East Java, 65144, Indonesia
Email: rimaromadhona065@gmail.com

***Beti Istanti Suwandayani (Corresponding Author)**
Department of Elementary Teacher Education, Faculty of Education, Science, and Humanities,
Universitas Muhammadiyah Malang,
Jl. Raya Tlogomas No. 246, Malang, East Java, 65144, Indonesia
Email: beti@umm.ac.id