Ethnomathematics Learning Model Based on Motifs of *Dayak Ngaju* Central Kalimantan

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Abstract: Mathematics education in the Dayak Ngaju, Central Kalimantan community played an essential part in its inherent culture, including batik/carving/painting motifs. The moral messages embedded in these motifs serve as the philosophy of life for the Dayak Ngaju community. This study aimed to describe influence of implementing an ethnomathematics learning model based on these motifs on students' learning outcomes and responses. The research used a mixed-method approach with an explanatory design. The research subjects consist of two 9th-grade classes, which were treated to un-purposed selection out of eleven classes in one of the public junior high schools in Palangka Raya, Central Kalimantan, Indonesia. The instruments included post-test, questionnaire (quantitative data), worksheet and interview guide (qualitative data). The results indicated the implementation of this model influenced the learning outcomes. The students also responded positively to the implementation of the model. They felt challenged to solve problems, answer questions, or complete tasks in the worksheet. Furthermore, students were motivated to develop a positive attitude by creating practical videos showcasing positive attitudes and paintings of the Dayak Ngaju motifs.

Keywords: Dayak Ngaju motifs, ethnomathematics, learning outcomes, local wisdom, students' worksheet

INTRODUCTION

Mathematics is a universal language that is merged within cultures. The integration of mathematics and cultures is known as ethnomathematics (Prahmana & Istiandaru, 2021). Research had shown that learning based on ethnomathematics is more readily accepted by students. The condition caused by the culture was an inseparable part of student's everyday life. Additionally, ethnomathematics made learning more engaging by applying it in the real-life context of the local community. Such learning conditions could enhance mathematics learning outcomes

(D'Ambrosio, 1985; Risdiyanti & Prahmana, 2020). Therefore, mathematics education needs to be united by local culture and wisdom.

One of the communities that still practices local culture and wisdom in everyday life is the Dayak Ngaju, one of the largest ethnic groups in Central Kalimantan, Indonesia. For example, in addition to resolving societal issues using the official laws of Indonesia, the customary leader of the Dayak Ngaju community, known as *demang*, also plays a role in their resolution. *Jipen* (fines/penalties), imposed by the *demang*, are applied to any individual who violates customary law. Furthermore, local wisdom such as *pintar tuntang harati* (intelligent and well-behaved), *belom bahadat* (living ethically), *handep* (collaboration), and *isen mulang* (perseverance) are educational norms within the Dayak Ngaju society (Usop et al., 2012).

Several studies aimed to explore ethnomathematics within the culture of the Dayak communities, in general, on the island of Borneo. First, a study focused on the *Dadas Bawo* Dance of the Dayak Ma'ayan tribe in Central Kalimantan. The findings revealed that the hand movements, footwork, and formations in the *Dadas Bawo* Dance incorporated concepts of angles (acute, obtuse, and right angles), parallel lines, geometric shapes (triangles and circles), and geometric transformations (reflection, rotation, and translation) (Mangkin, Agustina, & Huriaty, 2021). Second, ethnomathematics research explored the *nugal* tradition of the Dayak Sebaruk community in Jentawang, Ketungan Hilir, West Kalimantan. The result indicated the tradition of *nugal* involved mathematical concepts such as mathematical logic, sequences and series, geometric transformations (translation and reflection), and distances between points (Dian, 2021). Third, the research focused on the wedding tradition of the Dayak Kanayatn community in the Toho sub-district, Mempawah Regency, West Kalimantan. The findings revealed that the dominant mathematical concept within this tradition was counting. This concept was evident when the ceremony leader recites *asa dwa talu ampat lima anam tujuh* at the beginning of the *nyangahatn* activity. The use of seven as a number represents completeness (Eka, Sugiatno, & Munaldus, 2021).

There was only one study on ethnomathematics regarding the motifs of the Dayak Ngaju in Central Kalimantan. The motifs consisted of *batang garing* (tree of life), *tingang* bird (rhinoceros hornbill), *dandang tingang* (tail feathers of *tingang*), *jata* (dragon), plants, and animals. The research findings showed that the motifs incorporated objects and mathematical concepts. The concept of $x-$axis reflection was present in the motifs of *tanduk muang* (deer horns) and *dandang tingang*. The $y-$axis reflection was observed in the motifs of *batang garing*, *tingang* bird, *taya* tree, and *tanduk muang*. A 180^0 rotation around the point (0,0) was visible in the motifs of the *taya* tree and *buntut kakupu gajah* (elephant's tail). The translation was present in the *jata* motif. The motifs also included mathematical objects such as hexagons in the motifs of *tanduk muang*, or circles in the *jata* and the *batang garing* motifs (Mairing et al., 2022).

The inserted ethnomathematics to mathematics education can come in two ways. First, ethnomathematics can be a medium for a context for mathematical problems or projects. Second,

ethnomathematics can be beneficial to explore and develop a deeper understanding of mathematical concepts. For example, students can explore the geometric transformations to be present in the motifs using the GeoGebra application. In groups, students can set the motif as a background in GeoGebra. They can then identify four points within the motif, where two points come as the results of a geometric transformation from the other two. Furthermore, students can independently discover the moral values/local wisdom embedded in the motif and then apply the values in everyday life.

Several studies intentionally revealed to apply the learning approaches. First, a study examined the effectiveness of PBL (problem-based learning) in ethnomathematics using the motif of *sasirangan* fabric to improve students' problem-solving abilities. The results showed that students who learned with PBL-ethnomathematics had better problem-solving skills than those with traditional methods (Hidayati & Restapaty, 2019). Second, a study focused on practices of ethnomathematics-based instructional materials for junior high school students. The findings indicated that the instructional materials were suitable for mathematics learning (Gusfitri et al., 2022). Third, a study aimed to enhance creative thinking through ethnomathematics based in Surakarta batik. The results showed that this approach could improve students' creative thinking skills (Faiziyah et al., 2020). Fourth, a study aimed to enhance students' better understanding through ethnomathematics-based learning. The results revealed that students who learned using ethnomathematics had better comprehension than those who did not use ethnomathematics learning (Herawaty et al., 2019).

Searching using Google Scholar over the past ten years shows no studies integrating ethnomathematics in the Dayak Ngaju culture into mathematics education. As the research reveals, ethnomathematics in this context carries moral messages that need to be developed by students in the classroom. The moral messages of the ethnomathematics were embedded in the *batang garing* motif, for instance. The messages show that the universe is God's creation, so living beings should remember the Creator by caring for humanity. Also, it displays that the environment is formed as a unified entity. The motif of the *tingang* bird symbolizes purity, greatness, power, firmness, courage, loyalty, and responsibility. The motif of *dandang tingang* represents humanizing oneself by living with politeness and ethics (*belom bahadat*) towards fellow humans, plants, and animals. The *jata* motif serves as a reminder for humans to continue doing good throughout their lives. The motifs of plants and animals carries the moral value of humans caring for their environment and providing essential benefits in life (Mairing et al., 2022).

Therefore, the researchers intended to implement a learning model that integrated ethnomathematics in the Dayak Ngaju motifs. The implementation aimed to describe the process and learning outcomes of applying the model. Thus, the research questions formulated for this study are "Were the learning outcomes of students who learned using the ethnomathematics models based on the Dayak Ngaju motifs higher than 75 (scale 0-100)?" and "How did students respond to the learning with the model?". The results of this research will be beneficial for teachers

who intend to implement the model in developing higher-order thinking skills and positive attitudes.

METHOD

Research Approach and Design

The researchers used a mixed-methods research with an explanatory design. The collection of the data of the research was divided into two stages. The quantitative data were collected first, followed by qualitative data. The emphasis of the research findings was placed on the quantitative data, while the qualitative data was to provide explanations for the quantitative finding presentation. The research process involved several stages: formulating research questions for both quantitative and qualitative data, collecting quantitative data, collecting qualitative data, analyzing quantitative data, analyzing qualitative data, and producing the research report (Lodico et al., 2006).

The researchers implemented the ethnomathematics learning model to 9th-grade students in a public junior high school in Palangka Raya Central Kalimantan, Indonesia. The population for this research comprised all 9th-grade students in the selected junior high school. The students in the 9th grade learned the topic of geometric transformations incorporated in the ethnomathematics of the Dayak Ngaju motifs. The population framework consisted of eleven study groups in the 9th grade. In practice, the researchers applied the model to two study groups, which served as the samples for this research. The research sample was randomly selected using clustered random sampling technique, resulting in classes IX-10 and IX-11 as the groups for applying the model. The number of subjects in each class was 29 students.

Collecting Quantitative Data

The instruments used to collect the quantitative data were a post-test and a student response questionnaire. The post-test was applied to gain data on students' learning outcomes which later became the answer to the first research question, while the questionnaire was intended to obtain students' responses to the ethnomathematics learning model. The responses from the questionnaire became the answer to the second research question. The indicators and the questions in the questionnaire could be seen in Table 1. The post-test was as follows:

1. The given point $C(a,b)$ is reflected by line $x = 2$. The image is point $C'(5,7)$. Determine the value of $a + b$! Explain your answer!
2. The line AB is defined by the coordinates of points $A(-2,2)$ and $B(1,3)$. After the dilation, the resulting line becomes $A'B'$, where the point A' has coordinates $(-8,8)$ and B' has coordinates $(4,12)$. Determine the scale factor that was used! Explain your answer!

3. A tiger is hunting a deer in the forest. Based on the observation, the deer is located at point A, and the tiger is at point B. The deer then moves to point C.
   a. Determine the translation that represents the movement of the deer from point A to point C. Explain!
   b. If the tiger uses the same translation as the deer, will the tiger catch the deer? Explain!
   c. Determine the translation that the tiger needs to perform in order to catch the deer! Explain!
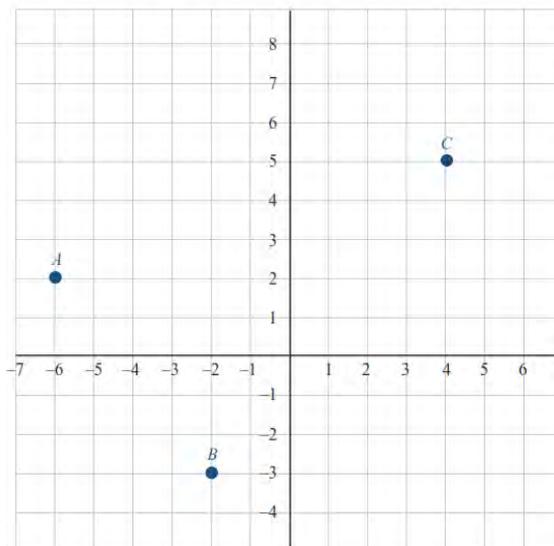
4. Shape A' is the result of a rotation with center $(0, 0)$ from shape A.
   a. Determine the angle of rotation!
   b. Prove that the rotation is correct by taking 2 points on shape A and show that their corresponding shadows on shape A' are in correct positions.
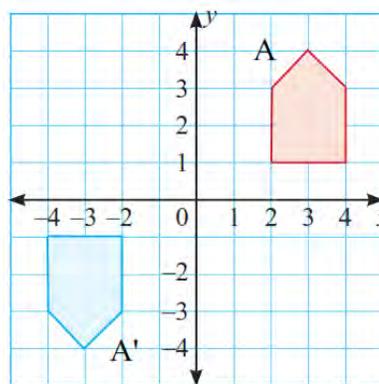
Questions number 1, 2, 3, and 4 represented the concepts of geometric transformations studied by the students, namely reflection, dilation, translation, and rotation.

Indicators	Number and Statements in the Questionnaire	Questions in the Interview Guide
1. Using the ethnomathematics model could help the students to develop a meaningful understanding of geometric transformations.	1. Using the learning model and the ethnomathematics worksheet has helped me understand the concept of geometric transformations. 6. I can understand the concept of geometric transformations after studying using the ethnomathematics model.	Do the learning model and the ethnomathematics worksheet help you understand the concept of geometric transformations? Why?
2. Using the ethnomathematics model could help	2. Using the model and the ethnomathematics worksheet helped	Do the learning model and the ethnomathematics worksheet help you develop

Indicators	Number and Statements in the Questionnaire	Questions in the Interview Guide
students to develop HOTS (higher-order thinking skills).	me develop good mathematical skills. 7. My mathematical abilities improved after studying using the learning model and the ethnomathematics worksheet.	higher-order thinking skills? Why?
3. The cultural context and the motifs in the worksheet foster students' motivation to learn and to complete questions, tasks, problems, and projects written in the worksheet.	3. The cultural context and the Dayak Ngaju motifs in the ethnomathematics worksheet foster my motivation to learn and complete tasks in the worksheet. 8. I am interested in learning geometric transformations using the ethnomathematics worksheet because it is associated with the culture of the Dayak Ngaju community.	1. Does the cultural context in the model and ethnomathematics worksheet motivate you to learn geometric transformations? Please explain! 2. Which part of the model or the worksheet do you find most interesting? Please explain!
4. Using the learning model encourages students to be actively engaged in their learning.	4. Using the model and the ethnomathematics worksheet encourages me to engage actively and participate in group discussions. 9. I became actively involved in independent and classroom learning by using the model and the ethnomathematics worksheet.	Do using the model and the ethnomathematics worksheet motivate you to actively engage in learning in the classroom? Please explain!
5. Using the ethnomathematics model helps students develop their positive attitudes.	5. Using the model and the ethnomathematics worksheet helps me to appreciate others and my environment. 10. I am motivated to develop positive attitudes after learning using the ethnomathematics worksheet.	Does the moral message in Dayak motifs encourage you to practice it in living your life? Provide an example!
6. The sentences in the worksheet are easy to read, comprehensible, and unambiguous.	11. The sentences in the ethnomathematics worksheet are well-structured and understandable. 16. The sentences in the ethnomathematics worksheet are incomprehensible and confusing.	Are the sentences written in the ethnomathematics worksheet comprehensible? Explain!
7. The mathematical terms, symbols, and formulas are well-written in the worksheet.	12. Terminology, symbols, and mathematical formulas in the ethnomathematics worksheet are well-written.	Are the mathematical symbols in the ethnomathematics worksheet well-written?

Indicators	Number and Statements in the Questionnaire	Questions in the Interview Guide
	17. The ethnomathematics worksheet contains notations and formulas of geometric transformations that are comprehensible.	Can you provide an example?
8. The figures and the motifs in the worksheets are well-depicted.	13. The figures and the motifs in the ethnomathematics worksheet are well-depicted. 18. The ethnomathematics worksheet contains ambiguous and difficult-to-understand figures or motifs.	Are the figures and motifs in the ethnomathematics worksheet clear and visually appealing? Please explain!
9. The provided links in the worksheets are accessible to see the figures and motifs.	14. The links between the figures and the motifs in the ethnomathematics worksheet are easily downloadable. 19. The provided links in the ethnomathematics worksheet can be easy to click to see the figures and motifs.	Why are the images and motifs in the instructional materials not easily accessible using a link? What if we use QR codes instead?
10. The worksheet is applicable for learning activities in groups.	15. The ethnomathematics worksheet is suitable for learning in groups. 20. Completing tasks in the ethnomathematics worksheet becomes enjoyable in a group.	Is the ethnomathematics worksheet suitable for group discussions? Explain!

Table 1: Indicators, Statements in the Questionnaire, and Questions in the Interview Guide

A validity test was conducted by finding the correlation between each question and the total score. The result was a $p-$value of less than $.05$ for each question. Therefore, each question in the questionnaire was valid. Two questions were included for each indicator in the questionnaire to determine reliability. The test result showed a reliability coefficient of $r = .86$, indicating high reliability of the questionnaire (Ghufron, 2011). The valid and reliable instrument was filled out by the students through a Google Form at the following link: https://intip.in/etnomatematika.

Collecting Qualitative Data

The collection of qualitative data was conducted in two ways. First, the researchers provided the ethnomathematics worksheet (https://intip.in/LKPDetnomatematika) to the students in both classes. The worksheet was completed with guidance for the students to explore the concepts of geometric transformations, routine exercises, mathematical problems, and projects. Additionally, the worksheet included links to learning videos intended to support the guidance. The solutions by the students in the worksheet served as qualitative data used to address the second research question. Second, the researchers conducted interviews using questions in the interview guide listed in Table 1. Some additional questions depended on the student's answers during the interviews. The interviews involved two students representing classes IX-10 and IX-11 to obtain more data.

Quantitative Data Analysis

The quantitative data in the research consisted of post-test scores and questionnaire scores. Both data were presented in tables or summarized using measures of the central tendency and the data dispersion. Furthermore, the post-test scores were analyzed to conclude the following hypotheses:

$H_0: \mu = 75$
$H_0: \mu > 75$

where μ represented mean of the post-test scores. The result of the hypothesis test was intended to answer the first research question.

Qualitative Data Analysis

The qualitative data in the research consisted of students' solutions to questions, problems, or projects written in the worksheet, and the interview transcripts. Both qualitative and quantitative data became the answer to the first research question. The transcripts were coded for data triangulation. A conclusion should be supported by two different subject codes (source triangulation) or two different data sources, namely the interview transcripts and the questionnaire responses (method triangulation). Considering both triangulations assured the credibility of the obtained conclusion.

RESULTS

The implementation of the ethnomathematics learning model on the topic of geometric transformations was applied to five meetings in grade IX. The learning activities using the model in IX-10 and IX-11 were applied by a mathematics teacher. The learning activities consisted of two phases. They were before-class independent learning and face-to-face learning in the classroom. During the independent learning phase, the students engaged in self-directed learning groups using the ethnomathematics worksheet. The worksheet covered the activities to discover geometric transformation concepts, links to YouTube videos, routine exercises, mathematical problems, and projects.

In the face-to-face learning phase, the following activities took place.
(a) The students began the learning session with a prayer led by one of the students.
(b) One of the students read aloud the learning objectives stated in the worksheet.
(c) The teacher motivated the students by showing videos included in the worksheet.
(d) The teacher facilitated classroom discussions to help students understand concepts that they had not grasped during their independent learning or to address any difficulties encountered in the worksheet.
(e) The teacher presented problems with cultural or local contexts (ethnomathematics) in the worksheet.
(f) The students in their groups presented and explained their solutions to the class.

(g) The teacher facilitated further classroom discussions to deepen students' understanding and encourage them to find alternative answers or solutions.

(h) The students engaged in reflection and concluded.

(i) The teacher assigned independent learning tasks to be completed by the students before the next meeting.

One of the advantages emerging in the implementation was the students learning independently in groups to answer questions or complete given tasks in the worksheet to discover specific concepts or formulas. For example, the students learn using YouTube videos to find the results of reflections over the y −axis from several given points. The results were written and recorded in the worksheet. The students discovered patterns from the previous examples of reflections on three points to find the formula of reflection over the y −axis (Figure 1).

1. Pencerminan terhadap Sumbu-y

Berdasarkan ciri-ciri sebelumnya, gambar bayangan/hasil pencerminan terhadap sumbu-y (sumbu tegak lurus) menggunakan aplikasi GeoGebra. Ikuti caranya pada video YouTube di link: https://youtu.be/ivB8OsfaVM0, lalu kalian ulangi lagi pencerminan tersebut menggunakan laptop atau *smartphone* masing-masing. Catat hasilnya pada tabel berikut.

Titik	Titik Hasil Pencerminan (Titik Bayangan)
A(3,5)	A'(-3, 5)
B(2,2)	B'(-2, 2)
C(7,3)	C'(-7, 3)

Keterangan: titik bayangan biasanya disimbolkan menggunakan tanda "aksen", sebagai contoh A'.

Misalkan diberikan titik $P(x,y)$, maka titik hasil pencerminan terhadap sumbu-y (jawab berdasarkan pola tiga jawaban sebelumnya pada tabel di atas):

$$P(x,y) \xrightarrow{\text{pencerminan terhadap sb−y}} P'(-x, y)$$

1. Reflection over the-y–axis

Based on the previous characteristic, draw the resulting image from reflection over the axis (the vertical axis) using GeoGebra. Follow the means on the YouTube video at the link: https://youtu.be/ivB8OsfaVM0, then you repeat the reflection using your laptop or smartphone. Write the results in the following table.

Points	The Image Points of Reflection over the y–axis
$A(3,5)$	$A'(-3,5)$
$B(2,2)$	$B'(-2,2)$
$C(7,3)$	$C'(-7,3)$

Note: the image points are usually symbolized using ' sign, for example A'.

Let given point $P(x,y)$, then the image point of reflection over the y–axis is (use pattern in the answers in the table)

$$P(x,y) \xrightarrow{\text{reflecion over the } y-\text{axis}} P'(-x,y)$$

(Translated into English)

Figure 1: Students' Answer on the Worksheet to Find the y −Axis Reflection Formula

The discovered formula was applied to find geometric transformation concepts in ethnomathematics in the Dayak Ngaju motif (Figure 2).
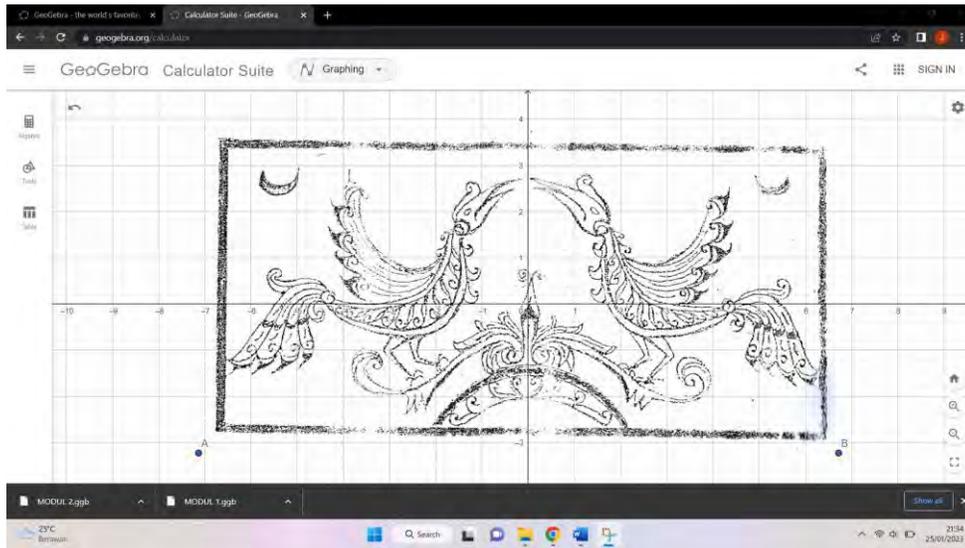
6. Apakah lukisan motif tersebut memuat **refleksi**? ......YA............

Jika ya, buktikan. Cara pembuktiannya dapat dipelajari melalui video YouTube di link: https://youtu.be/pRhz0vhWO7I. Tentukan dua titik lainnya menggunakan GeoGebra untuk memperkuat bukti bahwa refleksi ada pada motif burung *tingang*. Tuliskan buktinya pada tabel berikut.

Titik	Jenis Refleksi	Titik Bayangannya
(−1,4; 1,9)	Refleksi terhadap sumbu-y	(1,4; 1,9)
(-1,5, 1,4)	Sumbu-y	(1,5, 1,4)
(-7, 8.)	Sumbu-Y	(.7, 8.)

6. Does the *tingang* bird painting contain reflection? **Yes**
If yes, prove it. You can learn how to prove it through a YouTube video at the link: https://youtu.be/pRhz0vhWO7I. Determine two other points using GeoGebra to strengthen the evidence that the reflection is in the painting. Write the evidence in the following table.

Points	Type of Reflection	The Image Points
(−1,4; 1,9)	reflection over the y–axis	(1,4; 1,9)
(−1,5; 1,4)	y–axis	(1,5; 1,4)
(−7; 8)	y–axis	(7; 8)

(Translated into English)

Figure 2: Students' Solution on the Worksheet to Find Geometric Transformation Concepts in *Tingang* Bird Motif (Salilah, 1984)

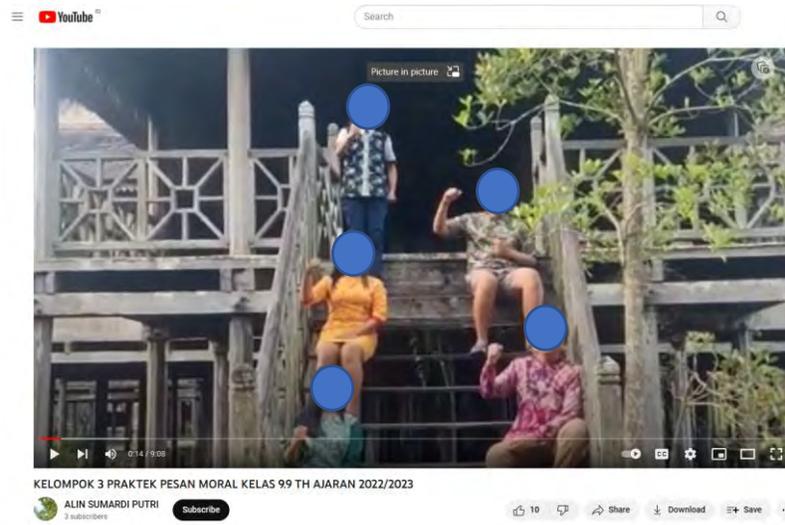Figure 3: Examples of *Dayak Ngaju* Motif Paintings was Made by the Students

Figure 4: Video of Moral Messages Practice in *Dayak Ngaju* Motifs

Furthermore, the students worked in groups to complete a project. The project was the students creating a drawing of the Dayak Ngaju motif accompanied by the moral message conveyed by the specific motif, and making a practical video based on the message. Examples of the drawings created by the students are presented in Figure 3. One of the sample videos is available to download from the link: https://youtu.be/ythCAVfB820 (Figure 4).

The students in both classes completed the post-test conducted after the implementation of the ethnomathematics learning model using the Dayak Ngaju motifs. The result showed the overall average score was 84.61 (scale of 0-100). Furthermore, 75% of the students' scores were equal to or above 78.57 (Q1), while the remaining scores ranged from 64.29 (minimum) to 78.57 (Table 2). An example of a student's answers to questions 1-4 is presented in Figure 5.

Classes	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
IX-10	29	87,44	7,31	64,29	85,71	92,86	92,86	92,86
IX-11	29	81,77	11,55	64,29	71,43	85,71	92,86	100
All	58	84,61	9,99	64,29	78,57	85,71	92,86	100

Table 2: Summary of Learning Outcomes After Implementing the Model

Jawaban Nomor 1 dari Siswa SS (Kelas IX-10)

Answer
The used formula for reflection over line $x = h$ as follows.
$A(x, y)$ be reflected over line $x = h$ is $A'(2h - x, y)$.
Note:
A : point A
A' : point A after reflection
x : point on x −axis
y : point on y −axis
h : number in line x.
As the point C is reflected over line $x = 2$ and resulting $C'(5,7)$, it means $h = 2$. To find point C', the formula is used:
$x' = 2h - x$
$5 = 2(2) - x$
$5 = 4 - x$
$x = -1$
If reflection over line $x = 2$, point y and y' are the same, so point C is $(-1,7)$. Thus, $a = -1$ and $b = 7$. The value $a + b = -1 + 7 = 6$.

The Answer for Number 1 from Student SS (Class IX-10)

Jawaban Nomor 2 dari Siswa CJ (Kelas IX-10)

2) Scale factor over x −axis $= (-8)/(-2) = 4$.
   Scale factor over y −axis $= 8/2 = 4$.
   Thus, used scale factor is 4.

The Answer for Number 2 from Student CJ (Class IX-10)

Jawaban Nomor 3 dari Siswa NP (Kelas IX-11)

3) $A(-6,2), C(4,5), B(-2,-3)$

a) $A(-6,2) \xrightarrow{\binom{x}{y}} C(4,5)$
   $-6 + x = 4 \qquad 2 + y = 5$
   $\qquad x = 10 \qquad\quad y = 3$
   Paired number of the translation from A to C is $\binom{x}{y} = \binom{10}{3}$.

b) No, the tiger can not catch the deer.
   $B(-2,-3) \xrightarrow{\binom{10}{3}} B'(8,0)$. Point C and B' are different.

c) $B(-2,-3) \xrightarrow{\binom{x}{y}} C(4,5)$
   $-2 + x = 4 \qquad -3 + y = 5$
   $\qquad x = 6 \qquad\quad y = 8$
   Paired number of the translation is $\binom{6}{8}$ for the tiger can catch the deer.

The Answer for Number 3 from Student NP (Class IX-11)

4. A. Sudut : 180°
  B. (2,1) dirotasi R (0,180°) adalah (-2,-1)
     (2,3) dirotasi R (0,180°) adalah (-2,-3)
     (3,4) dirotasi R (0,180°) adalah (-3,-4)
     (4,3) dirotasi R (0,180°) adalah (-4,-3)
     (4,1) dirotasi R (0,180°) adalah (-4,-1)

Jawaban Nomor 4 dari Siswa NM (Kelas IX-11)

4) A. The angle $= 180^0$.
    B. (2,1) rotated $R(0,180^0)$ is $(-2,-1)$
       (2,3) rotated $R(0,180^0)$ is $(-2,-3)$
       (3,4) rotated $R(0,180^0)$ is $(-3,-4)$
       (4,3) rotated $R(0,180^0)$ is $(-4,-3)$
       (4,1) rotated $R(0,180^0)$ is $(-4,-1)$

The Answer for Number 4 from Student NM (Class IX-11)

(Translated into English)

Figure 5: Examples of Students' Solutions to Numbers 1 – 4

The conclusion on the research hypothesis was drawn using the nonparametric Wilcoxon test. This kind of test was selected because the result of the Kolmogorov-Smirnov normality test yielded a p −value of less than $.01$, which indicated that the students' outcomes data were not normally distributed with a 95% confidence level. The Wilcoxon test result was a p −value of 0, meaning it was less than 0.05. The result indicated that the students' outcomes using the ethnomathematics learning model were greater than 75 by a 95% confidence level (Table 3).

Sample	N for Test	Wilcoxon Statistic	P-Value
NILAI	58	1535,00	0,000

Table 3: Wilcoxon Test Result for the Learning Outcomes using the Model

The sample of students' learning outcomes was influenced by the students' positive responses toward the indicators of effectiveness, readability, and practicality of the ethnomathematics model and the worksheet based on the Dayak Ngaju motifs. The average percentage of strongly agree or agree with responses to the indicators were 96.3%, 85.4%, and 95.8%, respectively (Table 4). However, there was one aspect that scored less than 80%, which was the easy access to the figures, the motifs, or the learning videos through the links in the worksheet. The aspect was improved by replacing the link-based accessibility with a QR code (Figure 6).

The positive response was also shown by the interview results of two students, namely AD (a female student from class IX-10) and CH (a male student from class IX-11). Both students responded positively to all the indicators in Table 1 (source triangulation) except for indicator 4. Both students stated that the ethnomathematics learning model could help students understand geometric transformations and develop higher-order thinking skills. Student AD said, "It helps make learning more varied, so it's not boring... we also learn about the connection between culture and mathematics, which makes it more interesting, challenging, and exciting". Student CH also stated, "It helps us learn geometric transformations because the learning incorporates the culture of batik, so we become more aware of the culture in Central Kalimantan... dilation in the batik

pattern requires us to think at a higher level". The interview transcript deals with the questionnaire result (method triangulation).

No	Indicators and Aspects	4 or 3	2 or 1
A	**Model Effectiveness**		
1	Using the ethnomathematics model could help the students develop a meaningful understanding of geometric transformations.	97,9	2,1
2	Using the ethnomathematics model could help students develop HOTS.	91,7	8,3
3	The cultural context and motifs in the worksheet foster students' motivation to learn and to complete questions, tasks, problems, and projects given in the worksheet.	95,8	4,2
4	Using the learning model encourages students to engage in their active learning.	97,9	2,1
5	Using the ethnomathematics model helps students develop positive attitudes.	100,0	0,0
C	**Model Readability**		
6	The sentences in the worksheet are easy to read, understandable, and unambiguous.	81,3	18,8
7	The mathematical terms, symbols, and formulas in the worksheet are well-stated.	91,7	8,3
8	The figures and the motifs in the worksheets are well-depicted.	91,7	8,3
9	The figures and the motifs are accessible through links provided in the worksheets.	77,1	22,9
B	**Model Practicality**		
10	The worksheet is applicable for group learning.	95,8	4,2

Note: 4 = strongly agree, 3 = agree, 2 = disagree, and 1 = strongly disagree

Table 4: Summary of the Students' Responses

(Translated into English)

Figure 6: Improvement Access after Implementation using QR Code

Furthermore, both students stated that the ethnomathematics learning model made students motivated and active in their learning. Student AD stated, "It motivates students to actively engage in learning because it is something new, exciting, and it makes us interested and challenged, which in turn makes us active". Student CH stated, "The ethnomathematics model makes mathematics interesting because it introduces new elements, and it is not merely learning mathematics but also exploring the culture of Central Kalimantan". Moreover, AD mentioned, "The interesting part is when we look for the moral message behind, for example, the *batang garing* motif, we explore its moral message, so we become more aware of this culture. The *batang garing* motif has a deep moral message that symbolizes the different worlds, the upper and lower worlds, which are different, but it is the same still for us as humans". Similarly, CH stated, "The most interesting part for me when I read about the discussion regarding the *tingang* bird, it had certain characteristics that symbolize something".

At indicator 4, there was a difference in responses. Student AD stated that the major constraint was it was difficult to access the provided links in the worksheet, while CH stated that the links were accessible. The links aimed to help students complete the exercises or tasks found in the worksheet. When the researchers was asked about their thoughts if the links could be replaced with QR codes, student AD said, "Yes, it is accessible, there is an application for it." Student CH mentioned, "I have scanned QR codes in the book before". Therefore, both students agreed that using QR codes would be more convenient, as they had experience using QR codes and found them easier to access.

DISCUSSION

Mathematics is a part of the culture inherent in the community. The integration is called ethnomathematics. A learning model based on ethnomathematics needs to be carefully designed so students can construct understanding meaningfully and develop higher-order thinking skills. Learning experiences or mathematics problems that students are involved with should be more realistic, reflecting everyday life, including the culture embedded in the community (Payadnya et al., 2021). Problems linked to cultural contexts helped students understand the problems better and formed mental images of the problem condition (Suherman & Vidákovich, 2022). This understanding and mental imagery helped students develop plans and implement them to solve the given problems (Ramadhani et al., 2022). The process helped students develop reasoning skills (Nursyahidah & Albab, 2021).

This research showed that the ethnomathematics learning model based on the Dayak Ngaju motifs influenced the learning outcomes. The impact was indicated by the average post-test scores being more than 75 (scale 0-100). The combination of several learning models with ethnomathematics could increase students' ability to solve mathematical problems. The increase occurred through self-reflection on problem-solving plans, monitoring, and evaluation of thinking processes

(Herawaty et al., 2018). Some of these models included contextual learning (Nur et al., 2020), realistic mathematics education (Lubis et al., 2021), inquiry-based learning (Putri & Junaedi, 2022), and problem-based learning (Zaenuri et al., 2020). Learning materials or worksheets based on ethnomathematics could also enhance students' critical thinking and creative thinking (Faiziyah et al., 2020; Imswatama & Lukman, 2018) and students' mathematical literacy (Agusdianita et al., 2021). Furthermore, the probing-prompting learning model based on ethnomathematics could improve students' abilities in mathematical communication and representation (Hartinah et al., 2019; Riwut et al., 2003; Widada et al., 2019).

The influence occurred because the students responded positively to the ethnomathematics learning model. The research showed that students responded to be motivated to engage in active learning because the learning became interesting. The practices of ethnomathematics-learning resources could also encourage students to learn actively (Imswatama & Lukman, 2018). This motivation and active involvement in learning help the students construct a meaningful understanding of mathematical concepts (Herawaty, Sarwoedi, et al., 2019; Herawaty, Widada, et al., 2019). The meaningful understanding became a factor that influences students' ability to solve problems (Mairing, 2018).

CONCLUSION

Mathematics education is inseparable from the context of everyday life, including the culture inherent in the community. The integration of culture in mathematics education is known as the ethnomathematics learning model. One of the cultures in the Dayak Ngaju community in Central Kalimantan is the batik/carving/painting motifs. The motifs are intertwined with daily life and carry specific moral messages, which serve as the philosophy of life for the Dayak Ngaju community. The Ethnomathematics learning model based on the motifs encouraged the students to actively engage in learning mathematics. The cultural context within the model made the learning process interactive and motivated students to solve questions, tasks, problems, and projects in the worksheet used in the model. Using the model also encouraged the students to acquire the moral messages embedded in the motifs. Therefore, the students responded positively to the implementation of the model. Such a learning environment had an impact on the students' learning outcomes. Moreover, the students produced products such as videos showing they practiced the moral messages (positive attitudes) and some paintings of the Dayak Ngaju motifs.

Expected future research will focus on developing a valid, effective, and practical ethnomathematics model based on the Dayak Ngaju motifs. The model should be applied to a broader school context and involve more participants, including the field operational trials. Additionally, ethnomathematics in the Dayak Ngaju community is not only limited to the motifs but also extends to the traditional dances, the technology of the Dayak Ngaju community, the traditional buildings called *betang*, and the calculation of societal days in the Dayak Ngaju community. The ethnomathematics learning model based on a holistic culture is needed by students to enhance high-order thinking skills and to acquire positive attitudes rooted in the culture (local wisdom).

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