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Weaving culture into Mathematics: How does integrating Kerawang Gayo ethnomathematics affect the concept of teaching reflections in junior high school?

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ABSTRACT: *Understanding mathematical concepts is a critical component of mathematics education. However, students' conceptual understanding remains relatively low, particularly with respect to topics related to reflection transformation. One instructional approach that may enhance students' comprehension is the integration of Kerawang Gayo ethnomathematics. This study aims to evaluate the effect of using instruction based on Kerawang Gayo ethnomathematics to improve students' understanding of mathematical concepts, specifically reflection transformation. The research employed a preexperimental design with a one-group pretest-posttest model. The population consisted of all ninth-grade students at a junior high school in Banda Aceh during the 2024-2025 academic year. A total of 28 students were selected as the sample via purposive sampling. The research instrument was a written test comprising five long-answer problems on reflection transformation. The data were analyzed via the Wilcoxon signed-rank test, followed by N-Gain analysis. The results indicated an improvement in students' conceptual understanding following the intervention, with an average N-Gain score of 0.604, which was categorized as moderate. These findings suggest that instruction incorporating Kerawang Gayo ethnomathematics may serve as an effective alternative for enhancing students' understanding of mathematical concepts.*

KEYWORDS: Conceptual understanding, ethnomathematics, Kerawang Gayo, reflection transformation.

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1. Introduction

Mathematics is a discipline that plays a vital role in the advancement of knowledge and serves as a foundation for various fields, including science, technology, and economics. It is a fundamental science and a universal language capable of expressing abstract ideas (Whitehead, 2017). Therefore, mastery of mathematical concepts is essential for the development of human reasoning and intellectual growth.

The role of Mathematics, such as number theory, algebra, and probability, serves as a fundamental basis for advancements in information and communication technology (Ningrum & Hasanudin, 2023). In modern life, increasingly sophisticated mathematical skills are needed. As Hayati (2022) asserts, in the 20th century, individuals who do not utilize Mathematics, even to a minimal extent, faced difficulties in navigating daily life. Therefore, Mathematics is essential for solving problems encountered in everyday situations. Problem solving requires a deep understanding of the mathematical concepts relevant to the problem; therefore, conceptual understanding is a critical aspect of learning mathematics. Without a solid grasp of concepts, students struggle to develop new material or solve mathematical problems effectively. Conceptual understanding serves as the foundation for building connections, communication, reasoning, and problem-solving skills (Aledya, 2019). It also plays a crucial role in linking existing knowledge with mathematical ideas in various contexts (Asti et al., 2022).

However, in practice, many students continue to struggle with conceptual understanding, particularly with respect to the topic of reflection transformation. Research by Agusna (2023) highlights students' low performance in solving geometry transformation problems, indicating limited conceptual understanding. This difficulty is largely attributed to teaching methods that emphasize memorization of formulas rather than fostering a deep comprehension of underlying concepts (Widyastuti et al., 2020; Surgandini et al., 2019). To date, teachers often rely on textbook images and fail to incorporate examples connected to students' real-life experiences, resulting in students' inability to relate mathematical concepts to their everyday lives.

One of the teacher's efforts to address these challenges is the use of a more contextualized learning approach. This approach involves selecting contexts that are familiar and meaningful to students, such as culture. The connection between culture and Mathematics is referred to as ethnomathematics. Ethnomathematics is an approach that explores how local cultures develop mathematical ideas through everyday practices (Prahmana & D'Ambrosio, 2020). Through this approach, students learn mathematics not only in abstract terms but also in ways that relate to their own cultural experiences. In this study, the cultural context used is *Kerawang Gayo*, a traditional decorative motif of the Gayo people in Central Aceh. Research by Hakim et al. (2020) revealed that *Kerawang Gayo* motifs contain mathematical elements, particularly the concepts of reflection and rotation within geometric transformations. In addition to introducing local culture, the ethnomathematical approach has also been shown to be effective in enhancing students' conceptual understanding (Narita et al., 2022; Azmi & Rosdiana, 2022).

Ethnomathematics has been the focus of numerous studies by various researchers. For example, Sulistyani et al. (2019) conducted a study on the ethnomathematical exploration of the traditional Tulungagung Joglo house. Edi (2021) investigated geometry transformations based on ethnomathematics in the traditional clothing of the Dayak Kenyah tribe, examining the geometric concepts present in both traditional houses and attire. Additionally, Ismail and Ismail (2010) explored ethnomathematical elements in *Alam Al-Hussab* and *Raudah Al-Hussab*, particularly focusing on the mathematical concepts of permutation and combination. Agusta (2021) examined ethnomathematics-based learning via Betawi culture to increase student creativity and engagement in geometry transformation topics, and Ramadhani et al. (2025) explored the integration of ethnomathematics into numeracy worksheets. Despite these studies, research on the integration of *Kerawang Gayo* ethnomathematics into Mathematics learning remains limited. The novelty of the present study lies in its focus on *Kerawang Gayo* as the contextual foundation. *Kerawang Gayo* is a traditional decorative motif of the Gayo people in Central Aceh that is known for its distinctive visual and philosophical characteristics, and it holds significant potential to deepen students' understanding of the concept of reflection in ways that may differ from other cultural contexts. The research question in this study is as follows: "Is there an improvement in students' understanding of the concept of reflection transformation through learning based on *Kerawang Gayo* ethnomathematics in junior high school?" This study aims to determine the extent to which learning on the basis of *Kerawang Gayo* ethnomathematics enhances students' understanding of the concept of reflection transformation in junior high school.

2. Literature review

2.1. Kerawang Gayo

Kerawang Gayo is both an ornamental motif and the name of traditional attire originating from the Gayo ethnic group in Central Aceh Regency, Aceh Province, Indonesia. The motifs in *Kerawang Gayo* possess philosophical meanings on the basis of their shape and size, conveying moral messages and ancestral values intended for future generations (Fitri, 2020). Thus, *Kerawang Gayo* represents a form of local wisdom rooted in Gayo culture. This aligns with the statement of Samodro et al. (2022), who explain that *Kerawang Gayo* serves as a life guide for the Gayo community, as it embodies principles and values that structure their way of life. The *Kerawang Gayo* motifs include *mata ni lo*, *tapak seleman*, *pucuk rebung*, *emun berangkat*, *emun berkune*, *puter tali*, *emun mutumpuk*, *emun mupesir*, *tekukur*, and *emun beriring* (Rosdiani & Chalid, 2022). The *emun berkune* motif symbolizes the making of agreements and decisions to resolve problems, whereas the *mata ni lo* motif represents the act of illuminating the universe, demonstrating patience in facing life's trials, and expressing gratitude for blessings (Iswanto et al., 2020). The *puter tali* motif reflects the unity and cohesion within Gayo society, the *emun berangkat* motif signifies solidarity in togetherness, and the *tapak seleman* motif conveys values of justice, wisdom, trust, and deliberation (Jusnimalita et al., 2022).

Figure 1. Puter Tali Motif (Hakim et al., 2020)

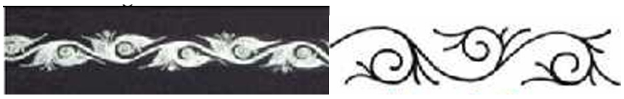

Figure 2. Emun Beriring Motif (Hakim et al., 2020)

The *emun beriring* motif symbolizes unity and togetherness, emphasizing the importance of not creating division. The *tekukur* motif conveys that every decision should be made with careful and wise consideration, whereas the *pucuk rebung* motif reflects the belief that every child must be educated by their parents to live harmoniously within society and contribute to nation-building (Hakim et al., 2020). The *emun mupesir* motif has a figurative meaning, representing population growth accompanied by the expansion of new territories. Moreover, the *emun mutumpuk* motif signifies the responsibility to arrive at customary decisions through collective deliberation (Nisfah et al., 2023).

Figure 3. Pucuk rebung motif (Hakim et al., 2020)

Figure 4. Tekukur Motif (Hakim et al., 2020)

2.2. Ethnomathematics-based Mathematics learning

Ethnomathematics-based Mathematics learning can serve as a manifestation of nationalism by fostering students' appreciation for and love for local cultures (Astuti et al., 2022). This approach not only introduces cultural elements to students but also enables them to learn Mathematics simultaneously (Nita et al., 2023). Through this process, students inadvertently engage with and apply the mathematical concepts embedded in cultural practices. Furthermore, implementing ethnomathematics-based learning supports cultural preservation by positioning culture not merely as a regional tradition but also as a meaningful context for instruction that reflects daily life (Irawan et al., 2022). Thus, the integration of ethnomathematics into Mathematics education represents a systematic effort to relate mathematical learning to students' lived experiences and cultural backgrounds, thereby enhancing the relevance and effectiveness of instruction. Mathematics learning that integrates ethnomathematics is an instructional approach that connects mathematical concepts with students' local cultures and traditions. By relating mathematical topics such as geometry, patterns, symmetry, and transformations to cultural elements, such as traditional Lampung dance, learning becomes more contextual, relevant, and engaging for students (Fatimah, 2024). This approach not only enhances students' understanding of mathematical concepts in a more concrete manner but also fosters motivation while developing their social, cultural, motor, and creative skills.

This approach helps bridge the gap for students who experience difficulties in visualizing mathematical concepts (Faturrahman & Soro, 2021). One area of Mathematics that relies heavily on visualization is geometric transformation. Examples of geometric transformations include translation (shifting), reflection (mirroring), rotation (turning), and dilation (resizing or changing the scale).

Reflection, or mirroring, in geometric transformation refers to the movement of points on a plane on the basis of the properties of mirror images. Research by Prahmana and D'Ambrosio (2020) demonstrated that the concept of reflection can be found in Yogyakarta batik motifs. Moreover, each motif embodies

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values and meanings that students can apply in their daily lives. On this basis, ethnomathematics not only serves as a visual representation of abstract mathematical concepts but also conveys cultural values embedded within each batik motif. An illustration of a Yogyakarta batik motif that incorporates the concept of reflection transformation is presented in Figure 5.

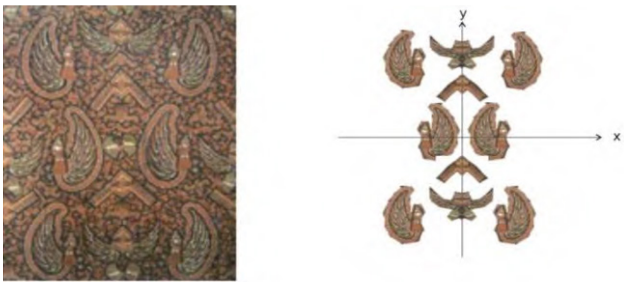

Figure 5. Reflection Transformation on the x-axis of the Bodhat Cement Pattern (Prahmana & D'Ambrosio, 2020)

2.3. Concept Understanding Ability

Concept understanding ability refers to the capacity to comprehend fundamental mathematical principles and apply them in various contexts. It also encompasses the ability to restate mathematical concepts in one's own words, classify mathematical objects, apply concepts algorithmically, interpret ideas or concepts, and relate different concepts to one another (Utomo & Wardani, 2021). A student is considered to have low concept understanding ability when they are unable to restate concepts, identify whether an object satisfies the conditions of a concept, provide appropriate and inappropriate examples of a concept, apply the concept correctly, or express it through mathematical representations (Ilmi & Utami, 2023). In other words, students demonstrate low concept understanding when they are unable to solve problems that require the application of conceptual understanding indicators. Concept understanding ability includes several indicators, as outlined by Ruqoyyah et al. (2020): (1) the ability to restate concepts that have been learned; (2) the ability to categorize objects on the basis of whether they meet the conditions for the formation of a concept; (3) the ability to apply concepts via algorithms; (4) the ability to provide examples and nonexamples of the concepts learned; and (5) the ability to communicate concepts via mathematical representations.

3. Methodology

This study employed a quantitative approach with a preexperimental design, specifically a one-group pretest–posttest design. This approach was selected to compare students' improvement in understanding mathematical concepts before and after the implementation of ethnomathematics-based learning via *Kerawang Gayo* on reflection transformation material. The research was conducted at a public junior high school in Banda Aceh during the first semester of the 2024–2025 academic year.

The study was conducted over five sessions at a public junior high school in Aceh, Indonesia. In the initial stage, the students were given a pretest consisting of five essay questions designed to measure their initial understanding of the concept of reflection transformation. The pretest was administered over 80 minutes, and the students' responses were tabulated via Microsoft Excel. In the subsequent sessions, the learning process continued using the discovery learning model combined with *Kerawang Gayo*-based ethnomathematics, which was specifically related to reflection transformation material. The learning began with an introduction to the cultural context that would be used throughout the lesson. The students were then divided into several study groups, with each group consisting of six students. They were introduced to real forms of *Kerawang Gayo* through traditional clothing and scarves provided by researchers. Students then engaged in group activities via student worksheets focused on the concept of reflection. These worksheets included *Kerawang Gayo* motifs that contain reflection transformation elements. In Figure 6, the yellow and green lines represent the axes of reflection in the *Kerawang Gayo* motif. Students were asked to observe the image and draw conclusions on the basis of their observations.

Figure 6. Kerawang Gayo Motif

The *Kerawang Gayo* motif helps students discover the properties of reflection transformation. The properties that students are expected to identify include the distance between objects and their reflections, the shape and size consistency between objects and their reflections, and the outcome of mirroring each motif across a given axis. To support this process, *Kerawang Gayo* motifs are presented on a Cartesian coordinate plane, as illustrated in Figure 7.

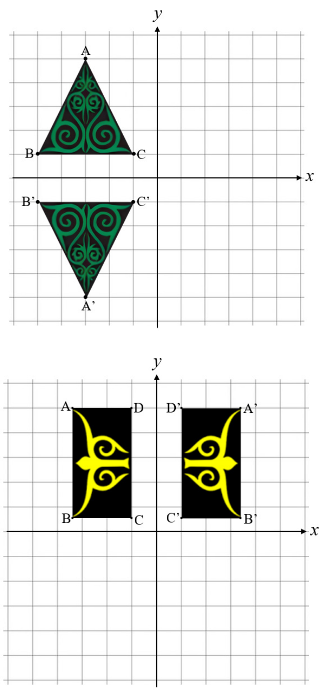

Figure 7. Kerawang Gayo Motif on the Cartesian Coordinate Plane

The next activity involves guiding students to discover the concept of reflection transformation on the *x*-axis and *y*-axis through tasks in the student worksheet. This activity presents the *Kerawang Gayo* motif on a Cartesian coordinate plane, as illustrated in Figure 8. Students observe the motif and identify the coordinates of specific points, namely, points A, B, and C. They then analyze the reflected image of the *Kerawang Gayo* motif after reflection across the *x*-axis, focusing on the coordinates of points A′, B′, and C′. By comparing the coordinates of the original points with their corresponding reflected points, students are expected to identify patterns of coordinate changes that occur during reflection over the *x*-axis and, ultimately, to formulate the general rule for reflection across the *x*-axis. The same process is applied to help students discover the concept of reflection transformation on the *y*-axis. Students determine the coordinates of the motif's original and reflected points and then compare them to identify the transformation rule for reflection across the *y*-axis.

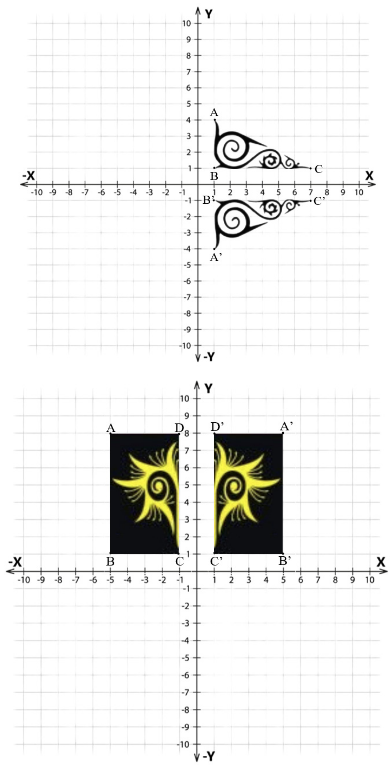

Figure 8. Reflection Transformation on the x-axis and y-axis

In the third meeting, the students explored the concept of reflection transformation to the origin, to the line $y = x$, and to the line $y = -x$. In the fourth meeting, they examined reflection transformation to the lines $x = H$ and $y = K$. The steps followed by the students were similar to those in the second meeting, in which the *Kerawang Gayo* motif was presented on a Cartesian coordinate plane. Students identified the original points of the *Kerawang Gayo* motif and their corresponding reflected points. By comparing each pair of original and reflected coordinates, the students discovered the transformation rules for reflections to the origin, the line $y = x$, the line $y = -x$, the line $x = H$, and the line $y = K$. The *Kerawang Gayo* motif used in the third meeting is shown in Figure 9, and the motif used in the fourth meeting is shown in Figure 10.

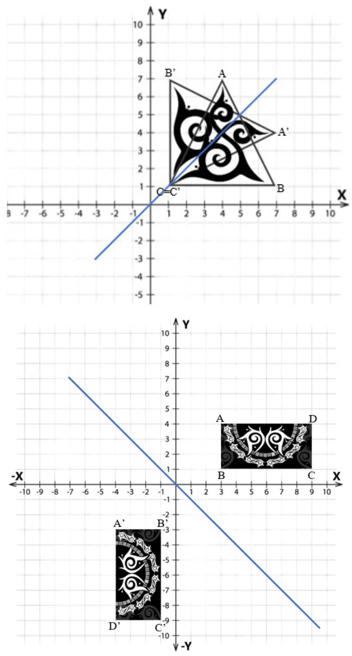

Figure 9. Reflection Transformation on Lines y=x and y=-x

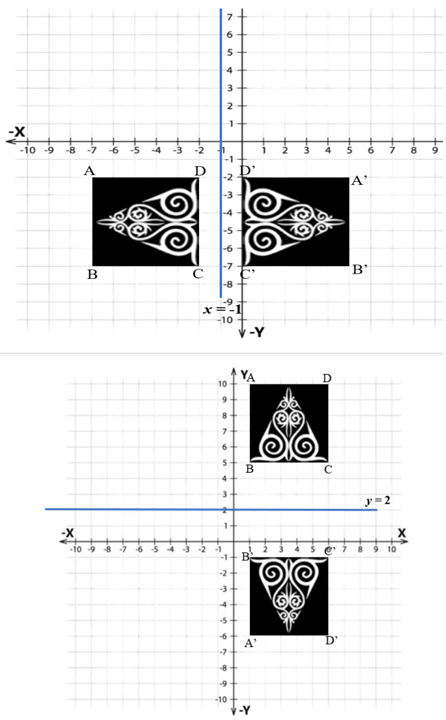

Figure 10. Reflection Transformation on Lines and

After three learning sessions, the students were administered a posttest using the same questions and duration as the pretest. The purpose of the posttest was to assess students' understanding of the concept of reflection transformation following the implementation of the treatment. The posttest data were tabulated for analysis.

A sample of 28 students was selected via purposive sampling. This class was chosen because the students had already learned the prerequisite concepts of geometry transformation, making it suitable for the research context. In addition, the class schedule allowed the study to be conducted consistently over five sessions. The number of students also met the minimum requirement for the statistical tests employed, making it representative for addressing the research objectives. The research instruments included written tests consisting of essay questions on reflection transformation, administered before (pretest) and after the treatment (posttest), with five questions in each test. A lesson plan and student worksheet were also used to support the implementation of the study. The test results were assessed on the basis of the scoring guidelines presented in Table 1, and the test items are presented in the appendix.

Table 1. Scoring Guidelines for Concept Understanding Ability Test

Description	Score
Did not provide an answer	0
Gives an answer by using methods, but the answer is not correct	1
Gives the correct answer, but without explanation	2
Gives an answer, but it is not entirely correct	3
Gives the correct answer with understandable reasons	4

Source: Tsany et al., 2020

The data collected were derived from students' responses during the administration of the pretest and posttest. Data analysis began with a normality test via the Shapiro–Wilk method to determine whether the data were normally distributed (Arikunto, 2018). If the data were normally distributed, a parametric statistical test was applied; otherwise, the Wilcoxon signed rank test, a nonparametric statistical method, was used to test the hypothesis. Additionally, an N-Gain calculation was conducted to measure the level of improvement in students' concept understanding, which was categorized as high, medium, or low. For the data analysis, the Shapiro–Wilk test and paired sample t test were performed via IBM SPSS Statistics version 23, whereas the calculation of the N-Gain scores was carried out via Microsoft Excel.

4. Results

A normality test was conducted to determine whether the data met the assumptions required for selecting the appropriate statistical test. The Shapiro–Wilk test was applied to the difference between the pretest and posttest scores, as it is suitable for small sample sizes. The analysis was performed via IBM SPSS Statistics 23, and the results are presented in Table 2.

Table 2. Shapiro–Wilk test results

Tests of Normality			
	Shapiro–Wilk		
	Statistics	**df**	**Sig.**
the_difference_of_the_pretest_and_posttest_variables	.975	28	.707

A normality test was conducted to determine whether the data met the assumptions required for selecting the appropriate statistical test. The Shapiro–Wilk test was applied to the difference between the pretest and posttest scores, as it is suitable for small sample sizes. The analysis was performed via IBM SPSS Statistics 23, and the results are presented in Table 2.

As shown in Table 2, the basis for decision-making is as follows: if the significance value is greater than 0.05, the data are considered normally distributed; conversely, if the significance value is less than 0.05, the data are not normally distributed. According to Table 2, the significance value is 0.707, which is greater than 0.05, indicating that the difference in the pretest and posttest variables is normally distributed. As a result, the paired sample t test was employed, as it is a parametric test that requires the assumption of normality. This test compares the means of two related groups to determine whether there is a statistically significant difference in their average scores. The results of this analysis are presented in Table 3 and Table 4.

As presented in Table 3, the mean pretest score was 29.11, whereas the mean posttest score increased to 71.96. The mean difference between the pretest and posttest scores was –42.857,

Table 3. Paired Sample Statistics

Paired Samples Statistics					
		Mean	**N**	**Std. Deviation**	**Std. Error Mean**
Pair 1	pretest	29.11	28	12.476	2.358
	posttest	71.96	28	13.077	2.471

Table 4. Paired Samples Test Results

Paired Samples Test									
Mean		**Paired Differences**					**t**	**df**	**Sig. (2-tailed)**
		Std. Deviation	**Std. Error Mean**	**95% Confidence Interval of the Difference**					
				Lower	**Upper**				
Pair 1	pretest - posttest	-42.857	18.630	3.521	-50.081	-35.633	-12.173	27	.000

with a standard deviation of 18.630. The results of the paired sample t test are presented in Table 4. The decision criterion applied was that if the significance value (Sig. 2-tailed) is less than 0.05, H_0 is rejected; otherwise, H_0 is accepted. As shown in Table 4, the obtained significance value is 0.000, which is lower than 0.05. Accordingly, H_0 is rejected, indicating a statistically significant difference between the pretest and posttest scores. This result provides evidence that the integration of Gayo Kerawang ethnomathematics had a significant positive effect on enhancing students' conceptual understanding of reflection transformations. Furthermore, the N-Gain test was conducted to assess the improvement in students' ability to understand the concept of reflection transformation before and after the treatment. The results of the N-Gain analysis are presented in Table 5.

Table 5. Wilcoxon signed rank test results

No.	Pretest	Posttest	N-Gain Analysis	Category
g1	15	60	0.5	Medium
g2	25	70	0.6	Medium
g3	25	80	0.7	High
g4	25	70	0.6	Medium
g5	35	90	0.8	High
g6	50	75	0.5	Medium
g7	45	75	0.5	Medium
g8	35	85	0.8	High
g9	15	80	0.8	High
g10	25	85	0.8	High
g11	35	70	0.5	Medium
g12	45	80	0.6	Medium
g13	25	55	0.4	Medium
g14	25	75	0.7	High
g15	20	80	0.8	High
g16	45	65	0.4	Medium
g17	25	80	0.7	High
g18	45	55	0.2	Low
g19	25	80	0.7	High
g20	25	40	0.2	Low
g21	5	80	0.8	High
g22	35	70	0.5	Medium
g23	45	50	0.1	Low
g24	5	80	0.8	High
g25	20	45	0.3	Medium
g26	35	70	0.5	Medium
g27	15	80	0.8	High
g28	45	90	0.8	High
	Average		0.6	Medium

Table 5 shows that the calculated average N-Gain score is 0.6. On the basis of Table 6, it can be concluded that the selected sample has an average N-gain level categorized as "medium". This suggests that the learning process based on *Kerawang Gayo* ethnomathematics effectively enhances students' conceptual understanding of reflection transformation material.

The students were able to understand the relationship between the *Kerawang Gayo* motif and the lines depicted in the images, enabling them to grasp the concept of reflection in a simple and relatable context. This finding indicates that students can visualize reflection transformation in concrete terms through the *Kerawang Gayo* motif. These findings are supported by research conducted by Andriono (2021), which highlights that one of the impacts of implementing ethnomathematics-based learning is fostering a perception of mathematics as enjoyable and applicable to everyday life. Additionally, Zuhra et al. (2021) reported that student worksheets developed via the ethnomathematics approach resulted in student scores that exceeded the minimum competency criteria. On the basis of these findings, ethnomathematics not only makes

Table 6. N-Gain Analysis

N – Gain	Category	Frequency	Percentage
	High	13	46%
	Medium	12	43%
	Low	3	11%
Total		28	100%

mathematics more engaging but also enhances students' learning outcomes. This is consistent with the findings of Payadnya et al. (2024), who stated that integrating cultural elements into mathematics learning can enhance students' understanding of mathematical concepts.

5. Conclusions

This study demonstrated that the integration of Gayo Kerawang ethnomathematics into mathematics instruction significantly improved students' conceptual understanding of reflection transformations. The results of the paired sample t test revealed a statistically significant difference between the pretest and posttest scores, while the average N-Gain score of 0.6 indicated a medium level of improvement. These findings confirm that incorporating local cultural elements into mathematics learning can serve as an effective strategy to enhance conceptual understanding while simultaneously preserving cultural heritage.

However, this study has several limitations. The research was conducted with a relatively small sample size of 28 students from a single school, which limits the generalizability of the findings. In addition, the use of purposive sampling means that the results cannot be claimed to represent the wider student population. Future studies should involve larger and more diverse samples, as well as different cultural contexts, to further validate and expand the findings.

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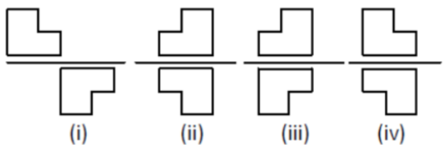
Appendix

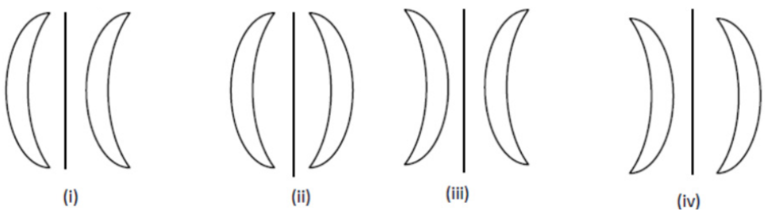
Pretest

1. Observe the figure below!



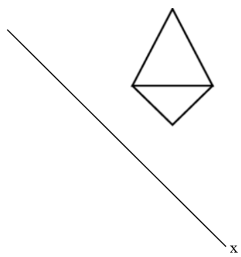
Which number correctly represents the reflection of the plane figure above? Write your explanation!

2. We observe the figure below!



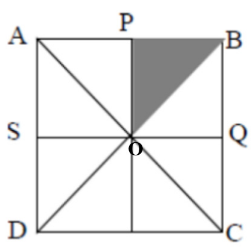
Which number correctly represents the reflection of the plane figure above? Provide your explanation.

3. We observe the figure below!



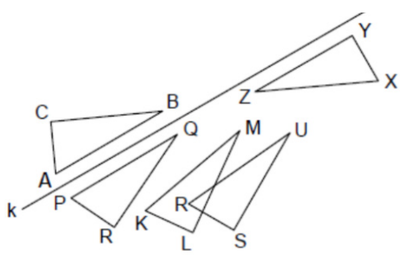
Draw the reflection of the figure above with respect to the x-axis!

4. The following square of ABCD!



If triangle BOP is reflected across the diagonal AC, what is the resulting figure?

5. Observe the following figure!

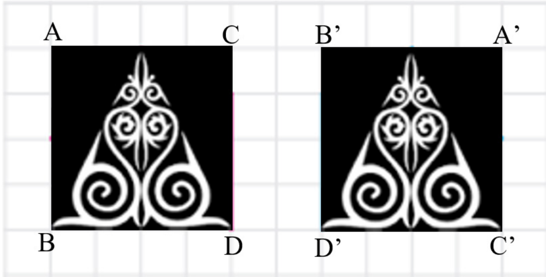


https://doi.org/10.15625/2615-8965/22510106

In the figure above, triangle ABC is reflected across line k (mirror k) to form which triangle? Provide an explanation!

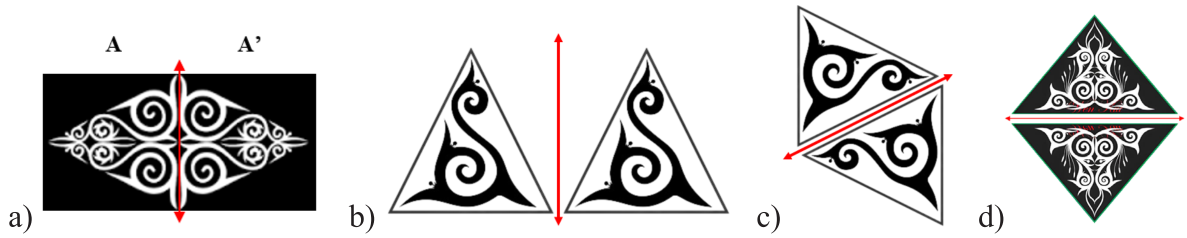
Posttest

1. Observe the following figure!

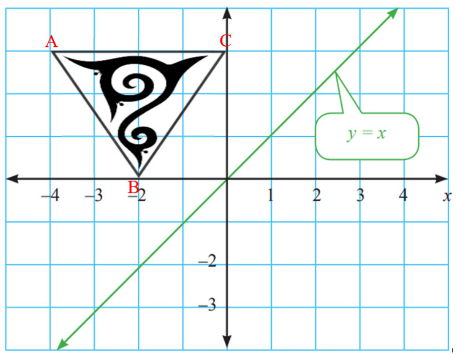


Is square A'B'C'D' the reflection of square ABCD? If yes, draw the reflection line!

2. Show whether the kerawang gayo patterns below are the results of reflection. Provide your explanation.



3. Triangle ABC is reflected across the line y = x. Triangle A'B'C' is drawn, and the coordinates of the reflected points are written.



4. The following Kerawang Gayo pattern is observed.

The motif is triangular. If the motif lies on the Cartesian coordinate plane with vertices at A(4, –2), B(4, 2), and C(6, –2), determine the reflection across the line y = x.

5. A kerawang gayo motif is given in the form of a quadrilateral KLMN with K(1,2), L(6,4), M(8,–3), and N(3,–1). The coordinates of quadrilateral K'L'M'N' are determined as the reflection of the KLMN across the line x = 3.