Jurnal Pendidikan Matematika
https://doi.org/10.22342/jpm.v18i3.pp387-408

The Characteristics of Teaching Materials that Promote Mathematical Abstraction through the Visualization of Minangkabau Batik Motifs

Dona Afriyani[1,*], Lailatul Ramadhani[2], Isra Nurmai Yenti[1], Elda Herlina[1]

[1]Prodi Pendidikan Matematika, Fakultas Tarbiyah dan Ilmu Keguruan, UIN Mahmud Yunus Batusangkar, Sumatera Barat, Indonesia
[2]SD IT Bustanul Ulum, Indonesia
[*]Email: donaafriyani@uinmybatusangkar.ac.id

Abstract

The ineffective use of constructivist learning through mathematical abstraction activities by teachers has led to low mathematics learning results. To promote mathematical abstraction, teaching materials must integrate the visualization of Minangkabau batik motifs. Therefore, this research aimed to describe the characteristics of teaching materials by adopting a 4D developmental model. The data analysis across the development stage included qualitative descriptive analysis for data received from interviews, observations, document reviews, and literature reviews, as well as quantitative descriptive analysis for data obtained from wide validation. The results showed that (1) Minangkabau batik motifs contained the concept of transformation geometry including reflection, rotation, translation, and dilation. (2) The characteristics of teaching materials included (a) having a cover, encouragement sheet, foreword, table of contents, materials, supporting information, exercises, assessments, and bibliography, (b) meeting the appropriateness of graphics, content, and language, (c) displaying the visualization of Minangkabau batik motifs for presentation of material, exploration of the properties of transformation geometry, and finding answers to prompting and practice questions, as well as (d) containing student activities in constructing concepts and making connections between such concepts. In conclusion, this research could help teachers improve students' mathematical abstraction using local cultures and teaching materials.

Keywords: Mathematical Abstraction; Minangkabau Batik Motifs; Teaching Materials Characteristics

How to Cite: Afriyani, D., Ramadhani, L., Yenti, I. N., & Herlina, E. (2024). The characteristics of teaching materials that promote mathematical abstraction through the visualization of Minangkabau batik motifs. *Jurnal Pendidikan Matematika, 18*(3), 387-408. https://doi.org/10.22342/jpm.v18i3.pp387-408

INTRODUCTION

Mathematics learning is currently oriented toward developing students' higher-order thinking skills. As a result, there is a need for comprehensive learning activities and tasks that encourage students to construct their concepts (Salmon et al., 2021). There is also a need for the use of teaching strategies that can guide students' thought processes to generate abstract ideas based on their existing knowledge (Andriani et al., 2022). Consistent use of these principles by teachers fosters meaningful thinking habits that allow students to adapt to the demands of the modern era. According to Hutagalung et al. (2020), abstract research objects, such as geometry, serve as a crucial aspect of mathematics. This condition enables mathematical learning activities to be presented using empirical abstraction procedures, particularly at the junior high school level. Empirical abstraction begins with the recognition of identical features in one's experiences, which is used as a foundation for developing conceptual schemes and classifying mathematical properties (Mitchelmore et al., 2007; Skemp, 2012). In other words, the process of empirical abstraction leads to the formation of concepts in students' minds. Kusuma et al. (2021) and Rytilä (2021) reported the importance of empirical abstraction processes in the constructivism paradigm.

Teaching materials that use static visual representations (Khasanah et al., 2019) and include

Received March 14, 2024; Revised August 5, 2024; Accepted August 19, 2024

mathematical concepts ranging from concrete to abstract models are critical elements of constructivist learning, acting as triggers for empirical abstraction processes (Sampoerno & Meiliasari, 2019). According to UNESCO (2015) that stated for creating teaching materials, teachers must consider both the topic and aspects of students' characteristics. The materials have to contain visual representations that have a relationship between images and mathematical symbols, ideas, and mathematical properties (Afriyani, 2020). Additionally, teaching materials contain activities that stimulate the emergence of gaps in the thinking process, allowing for the assessment of students' cognitive growth (Sa'dijah et al., 2018). The success of these materials is dependent on the compatibility with students' characteristics which allows the recognition and understanding of visual representations (Fitriani et al., 2018). The recognition enables students to easily understand the similarity of symbols and the nature of visual representations to construct mathematical objects and their relationships. Piaget (1999) stressed the importance of visual representations to initiate the abstraction process, which was based on students' social and physical experiences. As a result, designing effective teaching materials requires substantial teachers' experience.

Previous reviews showed that the performance of Indonesian teachers had not met expectations. According to the Ministry of Education and Culture (Sampoerno & Meiliasari, 2019), 80% of teachers failed the performance test results. Similarly, Jawa Pos (2021) suggested that teachers' willingness to use learning strategies cantered on mathematical thinking skills was insufficient. Mathematics teachers tend to prioritize the accuracy and correctness of mathematical content in students' written answers over understanding their thought processes (As'ari et al., 2019). This focus is a significant factor contributing to the low level of mathematical thinking skills in other countries.

From 2003 to 2022, Indonesian students consistently underperformed in Mathematics on the Programme for International Student Assessment (PISA). Throughout this period, their scores remained in the 300s (OECD, 2019; OECD, 2022), far below the PISA maximum score of 550. The Indonesian Minister of Education refers to the situation as an education crisis, which is also prevalent in West Sumatra. Preliminary research, including tests, assessment document reviews, and teachers interviews in several junior high schools, found that the percentage of students failing to meet mathematics learning objectives was higher than those who succeeded, consistent with the results of Johar et al. (2024). Students' inability to understand mathematical concepts and construct such concepts independently suggests that their mathematical abstraction process has not been fully constructed (Hutagalung et al., 2020; Rosmiati et al., 2021).

Research shows that an effective strategy to improve education is for teachers to bridge the gap between schools and real-world applications by using contextual teaching materials (Pathuddin & Raehana, 2019). According to ethnomathematics research, local cultures serve as effective contexts that can be adopted into teaching materials. Ethnomathematics has investigated a variety of local cultures, including *Sukapura Batik* (Mulyani & Natalliasari, 2020), Madurese salt production process (Hanik et al., 2024), and *Gringsing batik* motifs in Javanese culture (Permita et al., 2022). This analysis results showed that mathematical concepts related to local cultures comprised measurement, estimation, transformation geometry, permutations, combinations, and others.

Ethnomathematics research on Minangkabau culture has only examined the aspects of *Rumah Gadang* (Rahmawati, 2020; Fitriza, et al., 2017), custom houses, custom clothes, and traditional food (Daswarman & Sutadji, 2022), as well as *Songket* cloth (Syariannur, 2019). However, no investigations have been conducted on how to include Minangkabau batik themes in teaching materials design. The visualization of such motifs can help students comprehend and generalize batik motifs into formal mathematical concepts. This research aims to develop valid teaching materials for mathematical abstraction through the visualization of Minangkabau batik motifs. In addition, the purpose of this research is describing the characteristics of teaching materials that encourage mathematical abstraction through the visualization of Minangkabau batik motifs. The characteristics are formulated from the development process. The define stage of this development includes the exploration of mathematical objects within the visualization of Minangkabau batik motifs, which will be used to design teaching materials. The results of the exploration provide teachers with creative and innovative skills for delivering a mathematics-rich curriculum. These teaching materials can be used to present mathematical abstraction activities. Moreover, the materials contain the visualization of Minangkabau batik motifs that are familiar to students to increase their quality of mathematical thinking.

METHODS

This research used the 4D developmental model which had four stages, including define, design, development, and dissemination (Thiagarajan et al., 1974). However, the analysis failed to reach the dissemination stage. The define stage aimed to establish the reason for the need for teaching materials that promote mathematical abstraction through visualizing Minangkabau batik motifs. The activities carried out in this stage included conducting an initial investigation of the need for teaching materials, analysing objectives and mathematical materials, determining students' characteristics, investigating learning resources, and analysing mathematical content in the motifs. In the design stage, the process comprised setting specifications for teaching materials, designing drafts for the materials, and conducting self-evaluation. The development stage consisted of revising drafts based on the results of self-evaluation, validating teaching materials, revising based on validator suggestions, limiting the materials trials, distributing practical questionnaires to trial subjects, and making final revisions. This research did not report the results of the restricted trials and the practicality of questionnaires.

This research involved three experts, two experts in mathematics education and 1 expert is a mathematics teacher. The experts served as research subjects and informants who validated the research instruments. The methods used for the collection of data included interviews, observations, document analysis, and analysing batik images on long fabric, tablecloths, and garments, as well as engaging in discussions with validators and literature reviews. The instruments used consisted of interview guides, observation sheets, validity sheets, questionnaires, document analysis sheets, and literature reviews sheets. Validators or expert review were asked to provide an assessment on a scale ranging from 1 (not good) to 4 (very good). Data analysis in the development stage included qualitative descriptive analysis for data retrieved from interviews, observations, document reviews, and literature reviews, as well as descriptive statistics analysis for data obtained from wide validation.

$$\text{Percentage (\%)} = \frac{\textit{total gained score}}{\text{total maximum score}}\ x\ 100\ \% \qquad (1)$$

The results obtained could be grouped based on validity criteria, as shown in Table 1.

Table 1. Validity criteria

No	Achievement rate (%)	Category
1	81-100	Very valid
2	61-80	Valid
3	41-60	Less valid
4	21-40	Invalid
5	0-20	Very Invalid

(Source: Sarita, 2020)

Table 1 presented a total of five categories of validity of teaching materials. The characteristics of such materials were obtained from the results of the assessment that met the criteria for valid and very valid. Specifically, the characteristics designed to promote mathematical abstraction through the visualization of batik motifs would be detailed based on the data analysis conducted at the development stage, ensuring that the educational content met acceptable conditions.

RESULTS AND DISCUSSION

The analysis results showed the characteristics of teaching materials that promoted mathematical abstraction. These materials included transformation geometry content illustrated using Minangkabau batik motifs.

Define Stage of Development Teaching Materials that Promote Mathematical Abstraction through the Visualization of Minangkabau Batik Motifs

The results of the define stage showed that only one-third of students completed the learning transformation geometry. In the context of knowledge, learning results represented students' ability to explain the concept of transformation geometry. This showed that many students had not reached the new Bloom's taxonomy level of knowledge (C2). The issue was attributed to the learning process, the tools used, and students' learning styles.

In the learning process, class IX students were extremely passive in learning because they became silent when teachers asked questions, preventing multi-directional interactions. The only learning resource used was the 2013 curriculum mathematics textbook issued by the government, but it has not been fully used. Although textbooks have facilitated illustrations in the form of pictures and narratives, teachers have not used them to help students construct concepts. One of the reasons reported by teachers was that pictures in textbooks were not related to students' lives. The following presented the results of interviews conducted with mathematics teachers (MT).

MT : *I am not satisfied with the achievement of students' mathematics learning results. I believe this because the implemented learning has not activated students to construct mathematical concepts. One of my obstacles was that the learning resources used were not contextual and relevant to students' environment and culture.*

Based on observations of transformation geometry learning and interviews, students tended to have a visual and auditory learning style. Therefore, teaching materials were needed to present the concept visualization of transformation geometry in the form of local cultures, such as batik motifs. The format analysis of teaching materials showed the main elements, features, and stages of preparation. The primary components of these materials included covers, encouragement sheets, a preface, a table of contents, resources, supporting information, exercises, assessments, and a bibliography (Ulumudin, et al., 2017). This research provided an analysis of batik motifs from the perspective of mathematical objects. The analysis results produced mathematical content contained in Minangkabau batik motifs as explained below.

Mathematical Objects on Minangkabau Batik Motifs: Reflection Concept

Reflective batik motifs were found in the design including *Ajik*, *Kaluak Paku* (rolls of young fern shoots), *Aka Cino* (Chinese roots), *Pucuak Rabuang* (shoot of bamboo shoot), *Siriah Gadang* (Gadang betel), *Hong Bird*, *Itiak Pulang Patang* (ducklings return in the evening), *Rumah Gadang* (Gadang House), and *Bungo Malati* (jasmine flower). However, reflection was not observed in the design called *Lumuik Anyuik* (drifting moss) motifs because the shape was random. As shown below, *Ajik* motifs were used to explain the concept of reflection.

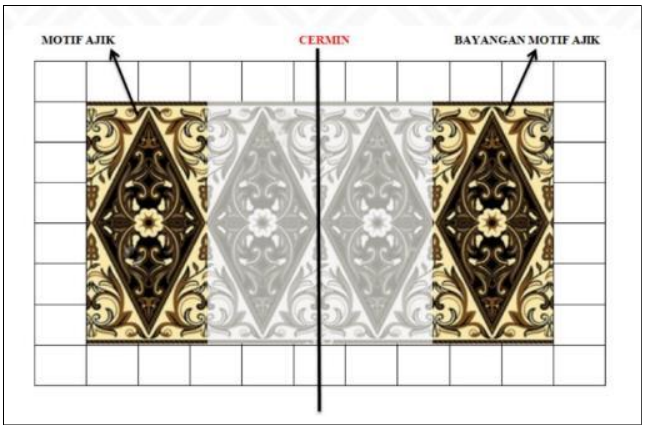


Figure 1. *Ajik* Motifs

 Jurnal Pendidikan Matematika, Volume 18, No. 3, September 2024, pp. 387-408

Figure 1 presented *Ajik* motifs formed by rhombuses lined up horizontally, referring to the concept of reflection. The other rhombus represented the reflection of the previous one. Reflection was considered a change of a point by moving it with the properties of a plane mirror. The characteristics included the equality of the distance between the point and the mirror and the distance between the image and the mirror, along with the mirrored geometric objects being oriented in opposite directions.

Reflection about the -x axis: (x,y) then (x, -y)

Reflection about the -y axis: (x,y) then (-x,y)

Reflection on the line y = x: (x, y) then (y, x)

Reflection on the line y = -x: (x, y) then (-y, -x)

Reflection on the line x = h: (x, y) then (2h, -x,y)

Reflex to line y = k: (x. y) find (x, 2k – y)

Mathematical Objects on Minangkabau Batik Motifs: Translation Concept

Rumah Gadang and *Itiak Pulang Patang* motifs were batik motifs that contained the translational concept. However, the visualization of motifs used to explain the concept of reflection was *Itiak Pulang Patang* motifs, as shown in Figure 2.

Figure 2. *Itiak Pulang Patang* Motifs

Figure 2 presented *Itiak Pulang Patang* motifs, which contained an image of a flock of ducks walking toward the drum. The motifs were related to the concept of translation, in which the second duck image was shown due to the changes in the previous image. The translation served as a movement or shift from a point to a certain direction in a straight-line plane. As a result, every plane in the straight line would be shifted in a particular direction and distance. The translation only changes the position, but not the shape and size of the field, and its formula was *(x',y') = (a,b) + (x,y). (x', y')* represented the shadow point, *(x,y)* indicated the origin, and *(a,b)* represented the translation vector.

Mathematical Objects on Minangkabau Batik Motifs: Rotation Concept

Siriah Gadang and *Bungo Malati* were the particular batik motifs containing rotation concepts, as presented in Figure 3.

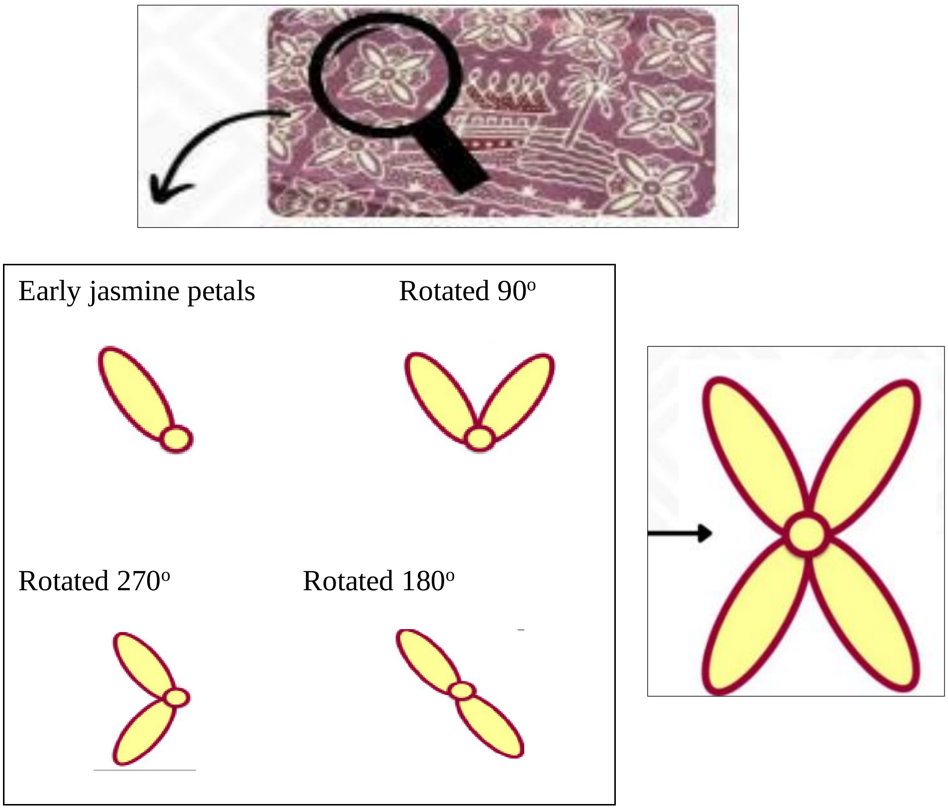


Figure 3. *Bungo Malati* motifs

Figure 3 provided *Bungo Malati* motifs formed by images of jasmine, coconut trees, and *Rumah Gadang*. However, such motifs were more dominant, containing images of jasmine, which had four petals. The second, third, and fourth petals were formed by a 90°, 180°, and 270° rotation of the first petal. This step showed that Bungo Malati batik motifs contained the rotation concept. The centre of rotation, the direction, and the magnitude of the angle were used to determine the rotation. This principle was to rotate the corner and the centre point, which had a similar distance to the rotated point. The transformation did not change the shape or size of an area.

Rotate 90° with centre (a, b): (x, y) then $(-y + a + b, x – a + b)$

Rotate 180° with centre (a, b): (x, y) then $(-x -2a, -y +2b)$

Rotation of 90° with centre (a, b): (x, y) then $(y – b + a, -x + a + b)$

Rotate by 90° with centre $(0, 0)$: (x, y) then $(-y, x)$

Rotate 180° with centre $(0,0)$: (x, y) then $(-x, -y)$

Rotation of 90° with center $(0,0)$: (x, y) then $(y, -x)$

Mathematical Objects on Minangkabau Batik Motifs: Dilation Concept

Pucuak Rabung and *Rumah Gadang* motifs was a particular batik motif that contain the concept of dilation. This pattern was related to the concept of dilation, a change in the size of an object. The two concepts in dilation included the point and the factor as shown in Figure 4.

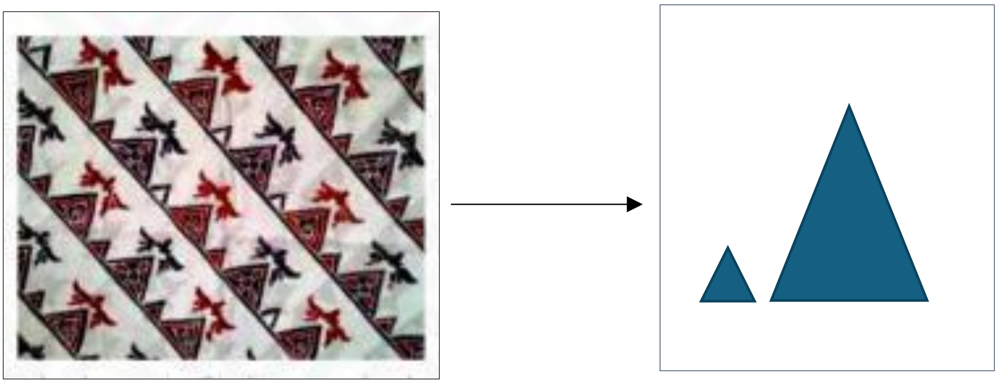


Figure 4. *Pucuak Rabuang* Batik Motifs

Figure 4 presented *Pucuak Rabung* batik motifs, which contained alternating patterns of small and large triangles. This pattern was related to the concept of dilation, a change in the size of an object. The two concepts in dilation included the point and the factor. The point concept determined the position of dilation, serving as the meeting place for all straight lines that connected points.

Dilation with centre (0, 0) and scale factor *k: (x, y)* then *(kx, ky)*

Dilation with centre (0, 0) and scale factor *k: (x, y)* then *(kx = k(x-a) + a, (k(y-b) + b))*

Ethnomathematics results concerning Minangkabau batik motifs complemented the research on the exploration of mathematical concepts in Indonesian culture. The similarity of the results was that Minangkabau batik motifs contain the concept of transformation geometry and batik motifs found in other tribes. Previous reviews included the exploration of ethnomathematics of *Sukapura Batik* (Mulyani & Natalliasari, 2020), *Grinsing Batik* Motifs (Permita, et al., 2022), *Songket* cloth (Syariannur, 2019), typical Yogyakarta batik motifs (Prahmana & D' Ambrosio, 2020), and others. This research made a unique contribution by describing the potential of visualizing Minangkabau batik motifs to channel students' mathematical abstraction thinking processes to effectively construct the concept of transformation geometry.

Design and Development Stage of Teaching Materials that Promote Mathematical Abstraction through the Visualization of Minangkabau Batik Motifs

Teaching materials were created using the Canva online application. In this creation process, the first stage was to establish a framework, which included determining the specifications of teaching materials based on the defined analysis results. The stage also consisted of determining the physical size of the materials, selecting the measurements of 1 x 15 cm with a thickness of 0.5 cm, selecting images of batik motifs used on the cover, layout, and the visualization of transformation geometry, as well as specifying a colour. The core stage comprised filling in each component of teaching materials in accordance with the specifications. The final stage included self-evaluation by making a checklist of the suitability of teaching materials with specifications. Self-evaluation results found that the color between the image and the background was not similar. The colour scheme was changed to create a more attractive and elegant appearance. In addition, the task component was altered to promote students' creativity by introducing assignments to draw batik motifs using the concept of transformation geometry. The results of designing teaching materials included the following. Firstly, teaching materials consisted of front and back covers, as shown in Figure 5.

Translated into English:

Transformation Geometry Teaching Materials Based on Minang Kabau Batik Motifs

Name :
Grade :
School :

Translated into English:

National Batik Day October 2
BATIK
was the cultural heritage of the archipelago that needed to be protected and preserved.
Batik must be introduced to the next generation of the nation.
As long as the Minangkabau people were close to their culture and vice versa, Minangkabau would remain sustainable.

Figure 5. Cover front (left) and back (right)

Figure 5 presented the front cover with a white background and it included batik illustrations of *Pucuak Rebung*, *Itiak Pulang Patang*, and the rotation of a yellow triangular shape. The front cover also showed students identity, class, semester, and level of education. However, the back cover had a white background with an orange border decoration. This back cover provided information on National Batik Day and words of wisdom regarding Minangkabau batik. Secondly, the encouragement sheet was designed with a white background with an orange pattern on the top left and bottom right. It contained motivational sentences, encouragement, learning mathematics, and local Minangkabau culture. The sentence was "cultural development affected education" and "once rowing two islands" (Minangkabau proverb), indicating that "once an activity was carried out, there would be understanding mathematical concepts and loving national culture."

Thirdly and fourthly, teaching materials included an introduction and a table of contents, with no specific explanation. Fifthly, teaching materials had content components that contained both learning objectives and materials. The objectives read, "Through exploring Minangkabau batik motifs, students could explain the meaning and characteristics of reflection, translation, rotation, and dilation", as well as solve contextual problems using the concept of transformation geometry. Learning materials covered four sub-materials, including reflection, translation, rotation, and dilation. Each sub-materials included learning materials 1, 2, and 3. Learning materials 1 began with an image introducing the reality of reflection, translation, rotation, and dilation, as shown in Figure 6.

Translated into English:

Reflection
Reflection of an object
When you look at the flower next to you, do you see its shadow on the water's surface? What was the shape of the flower and its shadow on the water surface?

Translated into English:

Translation
Translation of an object
Have you ever moved a table from one place to another like the picture beside?
When you have moved the table, the position of the table will change from the initial position to the end. The movement of the table is an example of a shift.

Translated into English:

Rotation
Rotation of an object
You must have seen a wall clock, right? If you pay attention, does the hand on the clock move? The movement of the clock hand is an example of rotation.

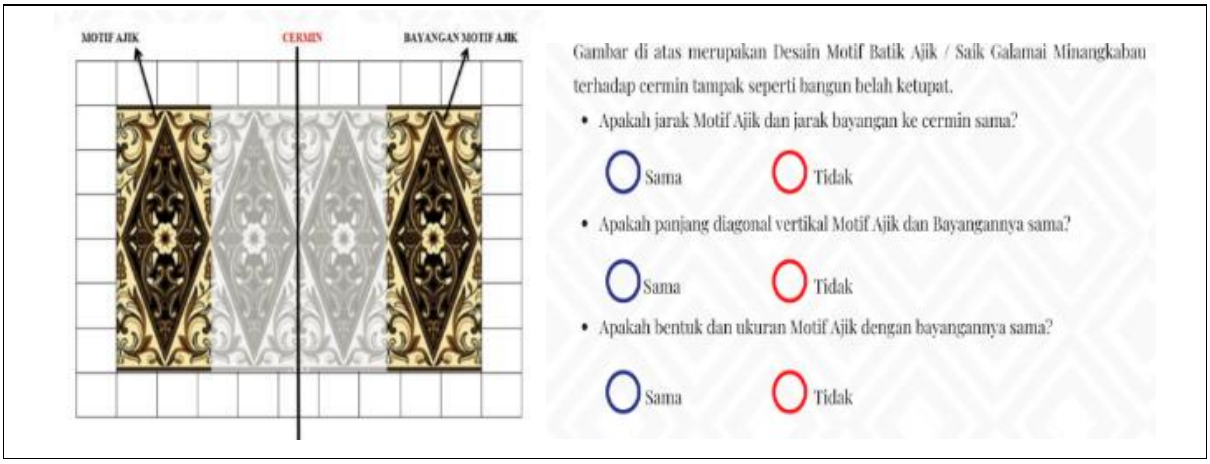
Translated into English:

Dilatation
Dilation of an object
A 4 x 6 photo is larger than a 3 x 4, and a 3 x 4 size photo is larger than a 2 x 3 size photo. the effort to enlarge the size of the same photo by increasing its size is called dilation.

Figure 6. Contextual image of the concept of reflection, translation, rotation, and dilation

Figure 6 presented the image of a lotus flower, and the shadow in the water was used to teach the reflection concept. The concepts of translation, rotation, and dilation were represented by a child pushing a table, a wall clock, and three passport images of different sizes, respectively. Figure 6 is a context that can be used to explain the concept of transformation geometry.

Learning materials 1 presented students' activities constructing concepts and geometric transformation properties from the visualization of Minangkabau batik motifs. The activities began by answering multiple-choice questions that focused on the characteristics of reflection, translation, rotation, and dilation. Students made conclusions about these concepts based on the results of previous activities. They were finally asked to fill in the blanks in the incomplete concluding editorial. Additionally, scaffolding was used considering that junior high school students tended to be at the enactive stage (Budiman, et al., 2023). Figure 7 provided that snippets of teaching materials were represented by learning materials 1 regarding the concept of reflection.



Translated into English:

The image above is a Minangkabau Ajik/Saik Galamai Batik Motifs Design that looks like a rhombus.
- Is the distance between the Ajik Motifs and their shadow the same? Yes or No
- Is the length of the vertical diagonal of the motifs and its shadow the same? Yes or No
- Are the shapes and sizes of Ajik motifs and their shadow the same? Yes or No

Translated into English:

Let Us Conclude Answer the following points correctly!

The image of a mirrored object had a shape and size that was… with the original motifs. The distance of the image of the object to the mirror was… with the distance of the object to the mirror. The image of the object in the mirror was mutually… with the original object The properties of the image of an object produced by reflection included the following.

1. The image of a mirrored shape had a size and shape that was… with the original.
2. The distance of the image given would be… with the distance of the original object to the mirror
3. The image of the shape in the mirror will be mutually… with the original building

Figure 7. Learning materials 1: Reflection concept

In Figure 7, students were asked to answer questions based on the results of observing the visualization of *Ajik* batik motifs. The questions included "Is the distance between *Ajik* motifs and their shadow the same?", "Is the length of the vertical and diagonal of *Ajik* motifs and their shadow the same?". The concluding activity contained the editorial properties of the shadows of objects resulting from reflection. The statement included (1) "the image of a mirrored shape had a size that was ... with the original", (2) "the distance of the image given would be ... with the distance of the original object to the mirror", and (3) "the image of the shape in the mirror would be mutually ... with the original building". Students were required to fill in the blank section as a performance of the construction results.

Learning materials 2 presented training activities that aimed to provide students with a deep understanding of the concept of transformation geometry. The exercise contained more than one task with different types for each concept. An example of a snippet of learning materials for the concept of translation was shown in Figure 8.

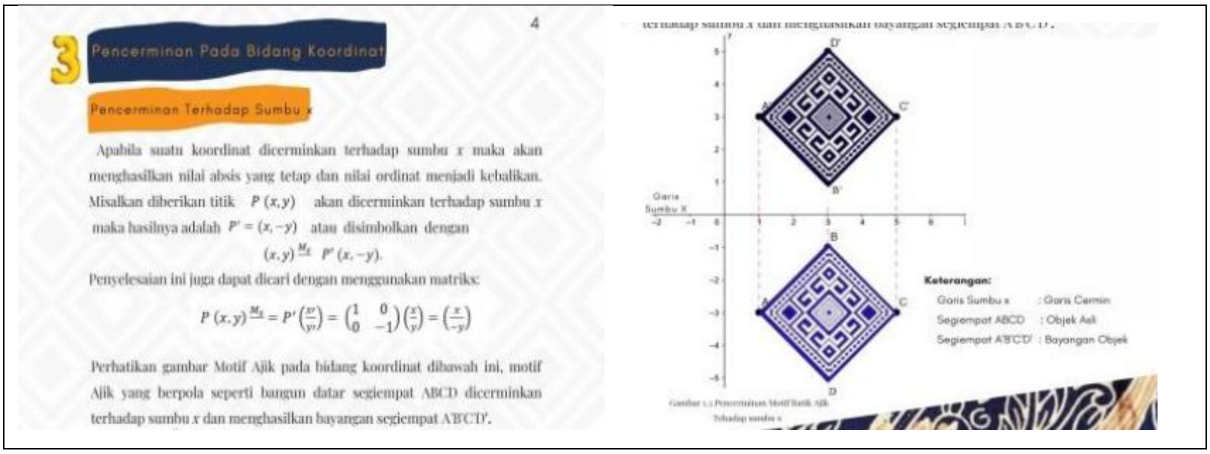
Translated into English:

Drawing the payoff of the shift result.

Now that you understand the properties of translational shadows, determine whether the blue image was a translational result of the red image, and give an explanation!

Figure 8. Learning materials 2

In Figure 8, there were two assignments regarding translation. Students were asked to determine whether the blue image translation resulted from the red one.



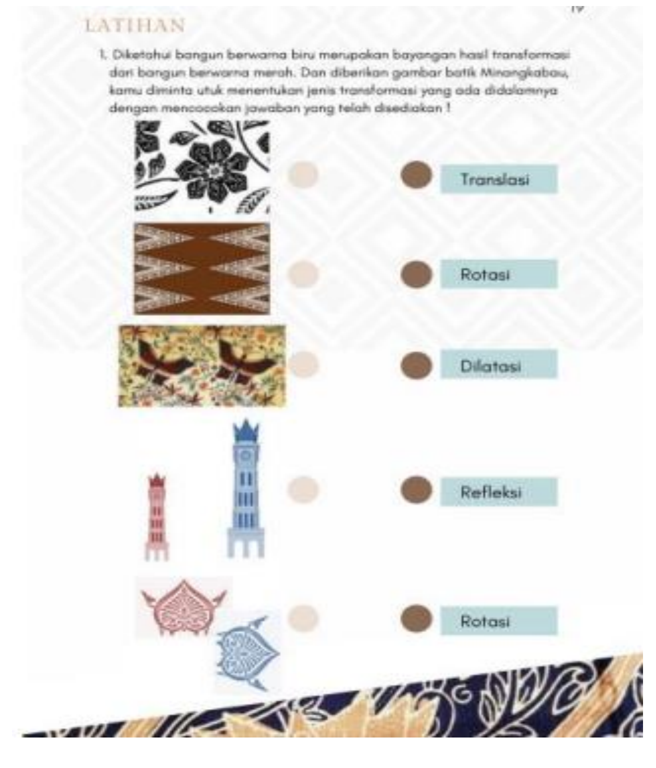
Translated into English:

Reflection on the Coordinate Plane
Reflection on the x-axis
If a coordinate is reflected on the x-axis, it will produce a fixed abscissa value and the ordinate value will be the opposite. For example, P (x, y) will be reflected on the x-axis, then the result is P (x, -y)
This solution can also be found using a matrix
Look at the image of Ajik motifs on the coordinate plane below, Ajik motifs which was patterned like a flat rectangular shape ABCD is reflected on the x-axis and produces a shadow of a quadrilateral ABCD

Figure 9. Learning materials 3: Reflection concept

Figure 9 presented learning materials 3 comprised the presentation of the materials. Students were asked to understand the materials that contained the formal concepts of reflection, translation, rotation, and dilation. In addition, there were students' activities to confirm their understanding through the assignments that were given by teachers. The following was a snippet of learning materials 3, which focused on reflection concept. In Figure 9, the formal concept of reflection was presented in verbal, symbolic, and graphic representations. These representations aimed to provide students with a flexible and deep understanding of the transformation geometry concept.

Sixthly, the exercise included in teaching materials aimed to determine the learning results of students' transformation geometry using Minangkabau batik motifs. Teaching materials contained exercises that test the knowledge and skills related to basic competence. The following Figure 10 was an example of the knowledge and skills exercise.



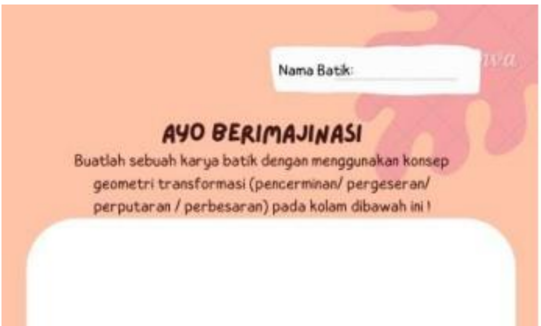
Translated into English:

1. Exercise
   It was known that the blue shape was the shadow of the transformation result and the red shape. Given a figure of Minangkabau batik, you were asked to determine the type of transformation in it by matching the answers provided!
   - Translation
   - Rotation
   - Dilatation
   - Reflection
   - Rotation

Figure 10. Exercise on knowledge competence

In Figure 10, the knowledge exercise consisted of four multiple-choice questions representing the entire materials of transformation geometry. The first question contained five pictures of Minangkabau batik. Students were asked to match the answers to the type of geometric transformation in the pictures. Furthermore, there were three multiple-choice questions regarding the materials in general, and the fourth question was related to Minangkabau batik motifs.

The skill exercise required students to make a batik work as an assessment of their skills in transformational geometry. The batik work was made using the principle of geometry. The following Figure 11 was a figure of skills training included in teaching materials.



Translated into English:

Batik Name : _________

Let's imagine

Create a batik work using the concept of transformation geometry (reflection/ translation/ rotating/ dilatation) in the column below.

Figure 11. Exercise on skill competence

In Figure 11, students were asked to imagine producing batik motifs by using the concept of transformation geometry. This activity can bring out the creativity of students in making various batik patterns using the concept of transformation geometry.

Seventhly, the assessment components of teaching materials functioned as good evaluation tools to measure the level of students' understanding of transformation geometry. The section provided questions in the form of multiple choice and essays, along with an answer key and scoring guidelines. Students were required to make Minangkabau batik motifs as part of their task. Eighthly, teaching materials featured supporting information, which contained several pictures of Minangkabau batik motifs consisting of *Pucuk Rebung*, *Ajik* or *Saik Galamai*, *Rumah Gadang*, and *Bungo Malati* motifs. There was also a narrative about the relationship between the transformation geometry and Minangkabau batik motifs. Figure 12 provided the supporting information on teaching materials.

Translated into English:

Did You Know?

Minangkabau batik motifs have their own characteristics, where the motifs reflect more cultural motifs, food, plants, animals and the uniqueness of Minangkabau people.

Translated into English:

According to the research results, Minangkabau batik motifs had a relationship with materials of transformation geometry because components, including points, lines, and planes, were the same.

What complements it was that Minangkabau batik was made with the results of the transformation of various forms of motifs to produce beautiful art.

Figure 12. Supporting information on teaching materials

In Figure 12, teaching materials provided insight into mathematics that was closely related to local cultures. It was believed that students would love the local Minangkabau culture. Lastly, the bibliography contained all reference sources that were used in making transformation geometry teaching materials based on Minangkabau batik motifs. These motifs included the name of the research book, title, publisher, and year of publication. At the development stage, expert validation was carried out by two mathematics lecturers and one senior mathematics teacher, as presented in Table 2.

Table 2. Teaching materials validation results

No	Aspect	Validator			Amount	Shoes Max	%	Category
		1	2	3				
1	Graphic Qualification	28	34	42	104	144	72,22	Valid
2	Content Eligibility	61	74	83	218	300	72,67	Valid
3	Language Qualification	28	29	35	92	120	76,67	Valid
	Amount	117	137	160	414	564	73,41	

In Table 2, teaching materials' graphics, content, and language met the valid criteria. The three validators provided notes on suggestions for improving teaching materials. These suggestions were grouped based on validation aspects in Table 3.

Table 3. Validator suggestions

No	Validation Aspect	Validator suggestions
1	Graphic Qualification	• Scale down the image on the front cover and replace it with an illustration of Minangkabau batik motifs that were undergoing transformation • Use the information on batik to present the initial apperception of transformation geometry learning • Replace the number line on the bamboo shoot batik motifs on materials 1 with a boxed background (grid)
2	Content Eligibility	• Replace the picture of question 3 with a flat shape related to Minangkabau batik • Use the editorial and illustrations of Minangkabau batik for each example of the questions presented • Use matching/cross-question for exercise no. 1 on teaching materials • Add Minimum Completeness Criteria for the scoring guidelines
3	Language Qualification	• Fix typing errors

Table 3 presented the validator's suggestions covering all three validation aspects and tended to be better on graphic and content aspects. This research made an improved contribution to teaching materials by referring to the contents of the table. Based on the validators' assessment, it was stated that the materials were in the valid category.

The Characteristics of Teaching Materials that Promote Mathematical Abstraction through the Visualization of Minangkabau Batik Motifs

Based on the validation results, this research found the characteristics of teaching materials that met the valid criteria. These characteristics included qualitative descriptions of graphics, content, and language aspects, promoting mathematical abstraction through the visualization of Minangkabau batik motifs. Observably, descriptors were derived from the items on the validation sheet, as shown in Table 4 the characteristics of teaching materials.

Table 4. The characteristics of teaching materials that promote mathematical abstraction through the Minangkabau batik motifs

No	Validation Aspect	Characteristics	Code
1	Graphic Qualification	a. The description of teaching materials was interesting and comprehensive	1a
		b. The presentation of pictures and illustrations was interesting and appropriate to the development of students	1b
		c. Did not include sentences, images, or the visualization of Minangkabau batik motifs that contain deviations from moral values	1c
2	Content Validity	a. The content of teaching materials was presented contextually in accordance with mathematics learning objectives	2a
		b. The descriptions and contents of teaching materials were reliable, accurate, and refer to correct material sources	2b
		c. The depth and breadth of the material was balanced and appropriate to the development level of students	2c
		d. The material of transformation geometry was introduced through the visualization of Minangkabau batik motifs	2d
		e. Learning materials presented student activities to explore the concepts and properties of transformation geometry from the visualization of Minangkabau batik motifs	2e
		f. Contained scaffolding multiple choice prompting questions based on the properties of reflection, translation, rotation, and dilation	2f
		g. Contained space where students communicate the concepts and properties of transformation geometry obtained from exploring activities and answering prompting questions	2g
		h. Included exercises that had multiple choice questions to enable students to use the concept of transformation geometry	2h

No	Validation Aspect	Characteristics	Code
		i. The questions in the exercise consisted of the visualization of Minangkabau batik motifs	2i
		j. The exercise also contained assignments that made students creative in drawing Minangkabau batik motifs by using the concept of transformation geometry	2j
		k. The exercise included assignments that helped students to be creative in drawing Minangkabau batik motifs by visualizing the concept of transformation geometry	2k
		l. Contained the insight that mathematics was closely related to local cultures to foster a sense of love for the local Minangkabau culture	2l
		m. Had connections between transformation geometry materials	2m
3	Language Qualification	a. Teaching materials were written using sentences that were effective, clear, communicative, and informative, as well as appropriate to the development level of students	3a
		b. Contained words and/or terms that were similar in accordance with the scientific discipline of mathematics along with the development level of students	3b
		c. Use good and correct Indonesian words in accordance with EYD	3c

As shown in Table 4, teaching materials that have been developed meet the strengths of teaching materials at an international level (Tim Oates-Assessment Research & Development, 2015; Liang & Cobern, 2013; UNESCO, 2015). In the aspect of content validity, teaching materials had the characteristics of promoting students' mathematical abstraction. The codes for the characteristics included 2d, 2e, 2f, 2h, 2i, 2j, 2k, and 2m. These characteristics covered mathematical abstraction activities that were needed for learning. They included observing the visualization of objects to show similarities in properties with a concept, fostering new experiences (Skemp, 2012), constructing relationships between objects from a particular point of view (Van Oers & Poland, 2007), forming a new concept based on experience and observation (Hutagalung et al., 2020), and solving problems as a result of thinking in the form of mathematical symbols, words, or diagrams (Fitriani et al., 2018). Furthermore, Khasanah et al. (2019) reported that activities in teaching materials consisted of recognition, representation, structural abstraction, and structural awareness.

The presentation of mathematical abstraction activities in teaching materials facilitated the visualization of Minangkabau batik motifs. This was reinforced by the research conducted by Dewi &

Agustika (2020) indicating that the presence of contextual and realistic media provided students with the opportunity to make connections between real experiences and formal mathematics. Further research was needed to assess the practicality of teaching materials and their impact on increasing students' mathematical abstraction. It was also recommended to prepare learning strategies containing activities that were synchronous with the characteristics of teaching materials, thereby ensuring the presence of mathematical abstraction in mathematics learning.

CONCLUSION

In conclusion, Minangkabau batik motifs contained the visualization of the geometric concept of transformation, showcasing the beauty of the motifs through reflection, rotation, translation, and dilation of cultural images such *as Itik Pulang Patang*, *Bungo Malati*, *Pucuak Rabuang*, and *Ajik*. The use of the visualization in teaching materials could be a medium for training and promoting students' mathematical abstraction skills. The materials met the characteristics of validity which included appropriateness of content, graphics, and language. The characteristics of teaching materials to promote mathematical abstraction depended on the suitability of the content. These characteristics included: (a) having a cover, encouragement sheet, foreword, table of contents, materials, supporting information, exercises, assessments, and bibliography, (b) meeting the appropriateness of graphics, content, and language, (c) displaying the visualization of Minangkabau batik motifs for presentation of material, exploration of the properties of transformation geometry, and finding answers to prompting and practice questions, as well as (d) including students' activities in constructing concepts and making connections between such concepts.

This research was useful for teachers to improve students' mathematical abstraction using local cultures and teaching materials. To fully realize the potential of the results, further research was needed to assess the practicality of teaching materials and their impact on increasing such abstraction. It was also recommended to prepare learning strategies that were synchronous with the characteristics of such materials, ensuring the presence of mathematical abstraction in mathematics learning.

ACKNOWLEDGMENTS

This research is an independently funded collaborative research. We would like to thank the validators consisting of experts and mathematics teachers who generously took the time and shared their knowledge.

REFERENCES

Afriyani, D. (2020). Development of leaflet based on the Bruner theory on the materials of the two-variable linear equation system [in Bahasa]. *Matematika dan Pembelajaran, 8* (1), 74-86. https://doi.org/10.33477/mp.v8i1.1303

Andriani, P, Kurniawati, K.R.A & Afriyani, D. (2022). A framework for assessing translation among multiple representations. *Jurnal Teori dan Aplikasi Matematika (JTAM), 6*(2), 321-330. https://doi.org/10.31764/jtam.v6i2.7193

As'ari, A.R., Kurniati, D., & Subanji. (2019). Teachers' expectation of students' thinking processes in written works: A survey of teachers' readiness in making thinking visible. *Journal on Mathematics Education*, *10* (3), 409-424. https://doi.org/10.22342/jme.10.3.7978.409-424

Budiman, P. M., Trimurtini, & Purwati, P. D. (2023). Implementing Bruner's theory for the conceptual understanding of addition and subtraction. *International Research-based Education Journal*, *5*(1), 119-127. http://dx.doi.org/10.17977/um043v5i1p119-127

Daswarman & Sutadji, E. (2022). Minangkabau ethnomathematics in primary school mathematics learning [in Bahasa]. *Jurnal Inovasi Pendidikan Dasar, 6* (1), 16-20. https://doi.org/10.36928/jipd.v6i1.862

Dewi, N. P. W. P. & Agustika, G. N. S. (2020). Effectiveness of mathematics learning through PMRI approach to mathematics knowledge competency [in Bahasa]. Jurnal Penelitian dan Pengembangan Pendidikan, 4(2), 204-214. https://doi.org/10.23887/jppp.v4i2.26781

Fitriani, N., Suryadi, D., & Darhim, D. (2018). Analysis of mathematical abstraction on concept of a three-dimensional figure with curved surfaces of junior high school students. *Journal of Physics: Conference Series*, *1132*(2018) 12037. 1-7. https://doi.org/10.1088/1742-6596/1132/1/012037

Fitriza, R., Afriyani, D., Turmudi, & Juandi, D. (2018). The exploration of ethno-mathematics embedded on traditional architecture of Rumah Gadang Minangkabau. 160 (Incomed 2017), 270–276. https://doi.org/10.2991/incomed-17.2018.57

Hanik, U., Efendy, M., Jannah, A. N., & Fatmawati, I. (2024). Ethnomathematics: Exploration of mathematical concepts on the process of Madurese salt production. *Jurnal Pendidikan Matematika*, *18*(1), 59–78. https://doi.org/10.22342/jpm.v18i1.pp59-78

Hutagalung, E.E., Mulyana, E., & Pangaribuan, T.R. (2020). Mathematical abstraction: Students' concept of triangles. *Journal of Physics: Conference Series*. 1521 (032106). https://dx.doi.org/10.1088/1742-6596/1521/3/032106

Johar, R, Moulina, A. R, & Away, Y. (2024). Development of e-learning based remedial videos on fraction in middle school. *Jurnal Pendidikan Matematika, 18*(1), 97-112. https://doi.org/10.22342/jpm.v18i1.pp97-112

Jariyah, A., Putri, R. I. I & Zulkardi. (2024). Development of learning video reflection using Palembang songket context to determine students' mathematical reasoning. *Jurnal Pendidikan Matematika*, *18*(2), 273-294. https://doi.org/10.22342/jpm.v18i2.pp273-294

Jawa Pos. Kemendikbudristek revealed average teacher competency score of 50.64 points [in Bahasa]. Page 1. Access on November 19, 2021 in address https://www.jawapos.com/pendidikan/01355273/kemendikbudristek-ungkap-ratarata-skor-kompetensi-guru-5064-poin

Khasanah, N., Nurkaidah, D. R., & Prihandika, Y. A. (2019). Learners' mathematical abstraction process in view of spatial intelligence [in Bahasa]. *Journal of Mathematics and Mathematics Education, 9*(2). 77-87. https://dx.doi.org/10.20961/jmme.v9i2.48396

Kusuma, J. K., Rachmad, I., & Hamidah. (2021). Constructivism from philosophy to mathematics learning. *International Journal of Economy, Education and Entre preneurship*, *1* (2). 58-63 https://doi.org/10.36928/jipd.v6i1.862

Mitchelmore, M. C., & White, P. (2007). Abstraction in mathematics learning. *Journal for Research in Mathematics Education*, *19*(2), 1-9. http://dx.doi.org/10.1007/BF03217452

Mulyani, E. & Natalliasari, I. (2020). Ethnomathematical exploration of Sukapura batik [in Bahasa]. *Mosharafa: Jurnal Pendidikan Matematika*. *9*(1). 131-142. https://doi.org/10.31980/mosharafa.v9i1.598

OECD. (2019). Pisa 2019 Results. PISA, OECD Publishing, Paris

OECD. (2022). Pisa 2022 Results (Volume I) The state of learning and equity in education. PISA. OECD Publishing. Paris.

Pathuddin, H. & Raehana, S. (2019). Ethnomathematics: Traditional Bugis food as a mathematics learning resource [in Bahasa]. *MaPan: Jurnal Matematika dan Pembelajaran*, 7 (2), 307-327. https://doi.org/10.24252/mapan.2019v7n2a10

Permita, A. I., Nguyen, T., & Prahmana, R. C. I. (2022). Ethnomathematics on the Gringsing batik motifs in Javanese culture. *Jurnal of Honai Math*, *5* (2), 85-108. https://doi.org/10.30862/jhm.v5i2.265

Piaget J. (1999). The construction of reality in the child. Psychology Press.

Prahmana, R. C. I., & D'Ambrosio, U. (2020). Learning geometry and values from patterns: Ethnomathematics on the batik patterns of Yogyakarta, Indonesia. *Journal on Mathematics Education*, *11*(3), 439-456.

Rahmawati, Y. Z. (2020). Realistic mathematics approach with ethnomathematics of Minangkabau Gadang houses on Pythagorean theorem material [In Bahasa]. *Jurnal Azimut*, *Edisi Khusus SMAR*, *3*(1), *22-29*. *https://doi.org/10.31317/jaz.v3iSMAR.636*

Rosmiati, R. N., & Ni'mah, K. (2021). Analysis of mathematical abstraction ability in terms of learning style Kolb assisted by Google Slides media. *Jurnal Math Educator Nusantara: Wahana Publikasi Karya Tulis Ilmiah Di Bidang Pendidikan Matematika*, 7(1), 26-36. https://doi.org/10.29407/jmen.v7i1.15675

Rytilä, J. (2021). Social constructivism in mathematics? The promise and shortcomings of Julian Cole's institutional account. *Synthese*, *2021*(199),11517–11540. https://doi.org/10.1007/s11229-021-03300-7

Sa'dijah, C., Afriyani, D., Subanji, S., Muksar, M., & Anwar, L. (2014). Assessing students' pseudo-mathematical translation using translation-verification model. *AIP Conference Proceedings,* 2014(1), 1–8. https://doi.org/10.1063/1.5054548

Sampoerno, P. D., & Meiliasari, M. (2019). Analysis of the mathematical learning materials with the characteristics of realistic mathematics education in the design research pre-service teachers' theses in Indonesia J. Phys.: Conf. Ser. *1402*(7), 1-7, https://doi.org/10.1088/1742-6596/1402/7/077105

Salmon, A. K., & Barrera, M.X. (2021). Intentional question to promote thinking and learning. *Thinking Skills and Creativity, 40* (100822).1-10, https://doi.org/10.1016/j.tsc.2021.100822

Sarita, R., & Kurniawati. Y. (2020). Development of students' worksheets (LKPD) for chemistry based on science generic skills [in Bahasa]. *Jurnal of The Indonesian Society of integrated Chemistry*, 12(1), 31-39, https://doi.org/10.22437/jisic.v12i1.7846

Skemp, R. R. (2012). The psychology of learning mathematics: Expanded American edition. Lawrence Erlbaum Associates, Inc: New York. https://doi.org/10.4324/9780203396391

Syahriannur. (2019). Exploration of ethnomathematics of Minangkabau songket fabric to reveal the philosophical value of mathematical concepts [in Bahasa]. *Jurnal Math Education Nusantara*, 2 (1), 58-63. https://doi.org/10.54314/jmn.v2i1.69

Thiagarajan, S., Semmel, D. S., & Semmel, M. I. (1974). *Instructional Development for Training Teachers of Exceptional Children*. Minneapolis, MN: Leadership Training Institute/Special Education, University of Minnesota.

Tim Oates-Assessment Research & Development. 2015. Textbooks–What are the features of a good textbook. Cambridge: University of Cambridge.

Ulumudin, I., Mardiansyah, & Joko, B.S. 2017. Textbooks and enrichment: Completeness and appropriateness of 2013 curriculum textbooks and policies for cultivating student reading interest [in Bahasa]. Jakarta: Pusat Penelitian Kebijakan Pendidikan dan Kebudayaan, Balitbang, Kemendikbud.

UNESCO. (2015). Textbooks and other education materials: what key messages do we want to convey and how?. France: UNESCO.

Van Oers, B., & Poland, M. (2007). Schematizing activities as a means for encouraging young children to think abstractly. *Mathematics Education Research Journal*, *19*(2), 10-22. https://doi.org/10.54314/jmn.v2i1.69

Liang, Y., & Cobern, W. W. (2013). Analysis of a typical Chinese high school biology textbook using the AAAS textbook standards. *EURASIA Journal of Mathematics, Science and Technology Education*, *9*(4), 329-336.