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DAMAR KURUNG CRAFTWORKS FOR GEOMETRICAL THINKING

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Abstract: *Damar Kurung* is one of the art works of Gresik Regency and has become a local cultural asset. From the making process to the use of the *Damar Kurung*, many features, objects, and activities can be identified as having mathematical elements. The present study is aimed at identifying mathematical objects and phenomena in the *Damar Kurung* that be used as instructional media to develop the five levels of geometrical thinking abilities with the different characteristics of learning achievements in each level. The study is qualitative research with the descriptive method. Data were collected by literary studies. Research results show that mathematical concepts found in the *Damar Kurung* that can be used as instructional media for developing geometrical thinking abilities are, among others, for Level 0: triangle and square flat shapes and angles and lines; for Level 1: side and space diagonals and parallelism; for Level 2: two parallel lines cut by a transversal line, Phytagoras theorm, and surface areas and volumes of cubes; for Level 3: lengths of side and space diagonals; and Level 4: distances among points, points to lines, points to spaces, lines to lines, and among spaces. These mathematical concepts are in a match with the learning outcomes of the Phase D in the National Curriculum.

Keywords: Damar Kurung, geometrical thinking, ethnomathematics

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INTRODUCTION

Many cultural items in Indonesia have close relation with mathematics learning including cultural rituals, art works, or regional habits and customs. These cultural objects or events can be used as a basis for making instructional media for specific course contents. One such art work is the *Damar Kurung* which is a cultural asset from Gresik Regency in East Java. Language wise, *Damar Kurung* consists of two words: *Damar* which means ‘lamp’/‘candle’ and *kurung* which has the meaning of ‘cover’; so, *Damar Kurung* stands for a lamp that has a cover around it (Meitasari & Alrianingrum, 2017). As a more precise description, *Damar Kurung* is a lantern in the form of a cube with no lower and upper sides; the sides are made from paper and the frame from bamboo (Wahyu, 2013). *Damar Kurung* is made and used to enliven the *Ramadhan* situation and entertain the Moslems while awaiting for the coming of the Tarawih evening prayer time (Meitasari & Alrianingrum, 2017).

The origin of the existence of the *Damar Kurung* lantern in the regency of Gresik is backgrounded by the existence of acculturation with Chinese cultures. Altough it originates from the same throught, *Damar Kurung* has its own uniqueness; besides its shape as a cube, it also has drawings of daily-life activities as habits of the Gresik people such as selling and buying in the market, religious activities, and entertainments other drawings specific of the Gresik society (Azis & Wahyuningsih, 2018). These pictures are not made randomly without meaning. On the contrary, the meaning that emerges from the drawings of the *Damar Kurung* can become moral messages for everybody and represent the values and images of Gresik Regency (Prayogo & Ismail, 2022). The formulation of images begins from the emergence of stimuli which later build perceptions or ideas of a certain meaning. These perceptions will later develop into knowledge about an object and, continuously, produce cognitions which will motivate an individual to take a stand in making behaviours and giving responses (Suryanto, 2016). For the existence of a relation between the drawings on the *Damar Kurung* and behaviour development, the choice of the *Damar Kurung* as mathematics learning media is accurate. *Damar Kurung* as a media for learning mathematics will provide stimulus to facilitate the process of constructing mathematical concepts (Octaviyanti & Wahyuni, 2023) .

Using the *Damar Kurung* in the learning of the cube shape will be able to build the geometric thinking abilities of the learners. Implementation of mathematic thinking in daily real life will not be realized if there are no objects that can be used as materials for improving learners' thinking abilities (Noto, Firmasari, & Fatchurrohman, 2018). Because geometry thinking is one of mathematics thoughts, this becomes transitive in nature. Building geometric thinking can also train other types of thinking such as logical thinking, systematic thinking, creative thinking, and so on (Fitriyani, Widodo, & Hendroanto, 2018). This is in agreement with what is stated by Hendriyanto, Kusmayadi, & Fitriana (2021) that geometry offers a lot of basic skills and helps in elevating deductive reasoning, logical thinking, problem-solving skills, and analytical thinking. Therefore, geometric thinking abilities have an active role in developing mathematic thinking.

Research on the mathematics concepts in the *Damar Kurung* has been conducted by Jenati & Mariana (2019) That study was aimed at exploring the concepts of mathematics in the making process of *Damar Kurung* and disclosing the opinions of the education stake holders in Gresik Regency concerning the results of the exploration. Results of the study showed that there were mathematics concepts of the *Damar Kurung* art work explored from two manners: the past experiences of the researchers and those of the researchers and the crafters. The uncovered mathematics concepts were, among others, whole numbers, operation of numbers, fractions, comparison, measurement units, points, lines, angles, fold symmetry, mirroring, flat shapes, congruency, space shapes, data display, and means which were in lines with mathematics learning competencies for the elementary school. These findings showed that there were mathematics concepts in *Damar Kurung* and that these could be used as alternatives in ethnomatics learning in the elementary school.

Based on the discussion above, it can be said that geomatric thinking is an ability that is important to develop and that, through the accurate choice of media, can be developed well. It is under this proposition that the present study is conducted to explore how geomatric thinking abilities can be developed through the *Damar Kurung* craftwork.

METHOD

The study is of qualitative research with the descriptive method. The data elicitation technique was a literature study by compiling books and journals related to *Damar Kurung* and geometric thinking abilities. The research proceeding included: 1) analyzing the mathematical concepts of the cube space shape that are related to *Damar Kurung*, 2) analyzing the levels of geometric thinking abilities according to the theory of Van Hiele, and 3) synthesizing between the mathematical concepts that can be found in the *Damar Kurung* and Van Hiele's theory of the levels of geometric thinking abilities.

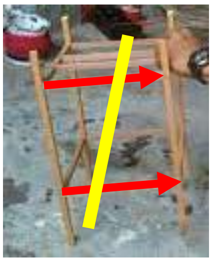
RESULTS AND DISCUSSION

Mathematics Concepts Related to *Damar Kurung*

The *Damar Kurung* is a lantern that resembles the form of the space shape of a cube; therefore, the mathematical concepts that will be discussed will be much close to the a concepts of the cube. However, it is not impossible that they are also close to other mathematics materials. These can be seen in the Table 1.

Table 1 Mathematical Concepts in the *Damar Kurung*

No.	Activity/Object	Mathematical Concept	Details of Mathematical Concept
The making of *Damar Kurung*			
1.	 (Samot Meliarni Nainggolan/Damar Kurung Gallery)	Numbers	Calculating the number of bamboo pieces for the frame of *Damar Kurung*
2.	 (damarkedhaton)	Angles	Recognizing angles from intersections of frames of *Damar Kurung*
3.	 (damarkedhaton)	Squares	Sides of the *Damar Kurung* that form squares
4.	 (damarkedhaton)	Space diagonals	Longest distance between two angle points in the *Damar Kurung*
5.	 (damarkedhaton)	Distance between a point and a line	Distance between an angle point of the frame and the frame of the *Damar Kurung*

No.	Activity/Object	Mathematical Concept	Details of Mathematical Concept
6.	 (damarkedhaton)	Distance between line and line	Distance between rwo frames of the *Damar Kurung*
7.	 (damarkedhaton)	Parallelism	Two frames of the *Damar Kurung* forming parallel lines
8.	 (damarkedhaton)	Two parallel lines cut by a transversal line	Two frames that are parallel cut by one frame or other objects (as transversal lines) resulting in relations of angles that are formed.
9.	 (Samot Meliarni Nainggolan/Damar Kurung Gallery)	Triangles	Additional ornaments on the top part of the *Damar Kurung* forming a triangle flat shape
After the Making			
10.	 (Sahlan Kurniawan/Oneimages)	Area of cube surface	By considering the top and bottom parts of the *Damar Kurung* are closed, area of the cube surface can be found by calculating the area of each of the area of the picture side of the *Damar Kurung*

No.	Activity/Object	Mathematical Concept	Details of Mathematical Concept
11.	 (Muhammad Khusnul Khuluk/@damarkurungfest)	Volume of cube	By considering the top and bottom parts of the *Damar Kurung* are closed, the volume of the cube can be calculated
12.	 (Sahlan Kurniawan/Oneimages)	Side Diagonal	Diagonal of each side of the *Damar Kurung*
13.	 (Sahlan Kurniawan/Oneimages)	Phytagoras Theorm	Sides of the *Damar Kurung* can be formed into two congruent right triangles which can be used to learn about the Phytagoras theorm
14.	 (Sahlan Kurniawan/Oneimages)	Distance between point and space	Distance between an angle point and a side of the *Damar Kurung*
15.	 (kibrispdr)	Rotational symmetry	Because each picture on the side of the *Damar Kurung* is different, this can be used to learn about rotational symmetries in a cube

Van Hiele's Theory of Levels of Geometrics Thinking Abilities

Geometrical thinking is the ability to use geometrical concepts in learning mathematics and various matters in real life. Geometrical thinking is related to how one uses reasoning using geometric figures and spatial relations. Furthermore, geometrical thinking can also help students develop critical thinking skills (Naufal *et al*., 2021). One of the impotant theories of the geometrical thinking which has often been referred to in the theories of thinking is that of Van Hiele's theory since the 1950s. The theory has been used as the basis of the contents of education in many countries including the United States of America, Russia, the Netherlands, Taiwan, and the Republic of South Africa (Ma *et al*., 2015; Pavlovičová, Bočková, & Laššová, 2022).

According to this theory, geometrical thinking abilities are distinguished into five levels; they are Level 0 (*visualization*), Level 1 (*analysis*), Level 2 (*informal deduction*), Level 3 (*deduction*), and Level 4 (*rigor*) (Hendriyanto *et al*., 2021). The following is the explanation of these levels.

a. Level 0 (*visualization*)

On this level, learners are able to visualize the geometric shapes according to their visual characteristics (Hendriyanto *et al*., 2021). Furthermore, according to Fitriyani *et al*. (2018), learners are able to understand the general features of the geometric shapes but not their characteristics. It means that, on this level, learners are able to group objects with similar shapes.

b. Level 1 (*analysis*)

On this level, learners know the characteristics of geometric shapes and are able to group them according to their general characteristics. They distinguish geometric shapes by mentioning all the chracteristics of the shapes including features that are even not needed (Pavlovičová *et al*., 2022). It can be said that, on this level of ability, learners are able to mention the characteristics or elements of the shapes and to classify them according to the characteristics, but they are not yet able to know the relationships among the shapes.

c. Level 2 (*informal deduction*)

On this level, learners begin to be able to find relationships between one shape and another according to the characteritics and elements of the shape. However, this ability is not fully developed (Fitriyani *et al*., 2018).

d. Level 3 (*deduction*)

On this level, learners are able to understand the interactions between requirements and adequacy and have the opportunity to find solutions to the problems that are faced

(Hendriyanto *et al*., 2021). Besides, as explained by Fitriyani *et al*. (2018), learners are able to understand the importance of the undefined elements among the defined elements of the shapes. On this level, learners are able to use axioms or postulates to prove many things. However, learners cannot tell why such axioms or postulates are to be used.

e. Level 4 (*rigor*)

On this level, learners are able to compare the different axioms to solve the same problems presented on the previous level. Pavlovičová *et al*. (2022) even state that learners also understand matters which are related to non-Euclid geometry. This thinking level is one which is high, difficult, and complex (Fitriyani *et al*., 2018).

Relations between the Mathematics Concepts in the *Damar Kurung* and Van Hiele's Levels of Geometric Thinking Abilities

Mathematics learning will be more meaningful and effective if the instruction uses media that are close to the learners' daily life. One of the principles is presenting ethnomathematics-based learning. Learning with ethnomathematics is not only more effective and superior than conventional approaches, but can also increase the acceptance of elementary school geometry learning materials (Abiam *et al*., 2016). By involving cultural elements familiar to the learners, they will not feel alienated with mathematics learning. In the previous section, descriptipn has been given of the various mathematics concepts that can be found on the *Damar Kurung* and *the Van Hiele's* five levels of geometrical thinking abilities. Table 2 contains an explanation of the relations between the mathematics concepts on the *Damar Kurung* and *Van Hiele's* levels of geometrical thinking abilities.

Tabel 2. Mathematics Concepts on the *Damar Kurung* on Van Hiele's Levels of Geometrical Thinking Abilities

Level of Geometrical Thinking Abilities	Mathematics Concepts on the *Damar Kurung* and Interpretation
Level 0 (*visualization*)	1. Rectangle and triangle flat shapes Learners are able to know and differentiate flat shapes according to their forms, but are not yet able to know the characteristics of the shapes, 2. Angles and lines Learners are able to know that two intersecting lines form an angle and to differentite angles from non-angles.
Level 1 (*analysis*)	1. Side diagonal and space diagonal Learners begin to be able to mention properties of squares and cubes. 2. Rotational symmetries of squares and cubes

Level of Geometrical Thinking Abilities	Mathematics Concepts on the *Damar Kurung* and Interpretation
	Cubes also have rotational symmetries. *Damar Kurung* has four sides with different pictures; so learners will be able to easily analyze the number of rotational symetries that squares and cubes have in smaller scales. 3. Parallelism Through the characteristics of a cube having parallel sides, learners will be able to learn the characteristics of parallel lines.
Level 2 (*informal deduction*)	1. Two parallel lines cut by a transversal line Learners will be able to understand the relation of angles formed by the intersecting of 2 parallel lines with a transversal line. 2. Phytagoras Theorm Using the characteristics of squares and triangles, with the teacher's help, learners will be able to prove the validity of Phytagoras Theorm through informal equation. 3. Area of surface and volume of a cube Learners will be able to estimate and determine the area of the surfaces and volume of the cube by knowing the characteristics of squares.
Level 3 (*deduction*)	Length of side diagonal, length of space diagonal Based on Phytagoras theorm, that has been learned, learners will be able to easily estimate the length of the side diagonal or space diagonal. In this phase, learners have known the necessary requirements and specific requirements why the Phytagoras theorm can be utilized.
Level 4 (*rigor*)	Distance of point to point, distance of point to line, distance of point to space, distances among lines, distances among spaces This material much uses related materials learned before; among others, Phytagoras theorm, parallelism, characteristics of angles and squares. Similar to the material for lengths of cube diagonals, for this material, learners also have to identify when to use Phytagoras theorm and when to use other ways.

From the foregoing description of the materials explored about the *Damar Kurung* and how they may be related to the geometrical thinking abilites in mathematics learning, the materials of the study, as can be seen in the table above, can be classified into the learning outcomes expected in the National Curriculum. All the decription of the learning outcomes above has been based on the Decree of the of the Head of the Body of Standard Curriculum and Educational Assessment, Ministry of Education, Culture, Research, and Technology (Kemdikbud, 2022) about learning achievements early-age children education, elementary-school level, and high-school level in the National Curriculum. In the present study, foci are given to the geometry materials and assessment of the junior high-school level or Phase D.

The determined learning achievement of the geometry element in Phase D is formulated as follows:

> "In the end of Phase D, learners are able to make the network of space shapes (prism, tube, pyramid, and cone) and make the space shapes from the network. Learners are able to use the inter-relations among angles formed by two intersecting lines and two parallel lines cut by a transversal line in order to solve the problem (including determining sizes of angles in a triangle, finding sizes of angles that have not been known). Learners are able to explain the characterisstics of congruence and shape similarities of triangles and rectangles, and use it to solve problems. Learners are able to show the validity of the Pythagoras theorm and use it in solving problems (including distance between two points on the Cartecian co-ordinate space). Learners are able to perform singular transformation (reflection, translation, rotation, and dilation) on points, lines, and flat shapes on points, and lines on Cartecian co-ordinate space and use it to solve problems)" (Kemdikbud, 2022).

The mathematical concepts on the *Damar Kurung* that are included in the learner achievement "Learners are able to make the network of space shapes (prism, tube, pyramid, and cone) and make the space shapes from the network" are the material of square flat shapes found in Level 0 (*visualization*); rotational symmetries of squares and cubes found in Level 1(*analysis*) ; and side diagonals and space diagonals found in Level 1 (*analysis*). This is because the *Damar Kurung* is an interpretation of cubes, and cubes can be included in the category of prisms. Then, the mathematical concepts found on the *Damar Kurung* that are included in the learner achievement "learners are able to use the inter-relations among angles formed by two intersecting lines and two parallel lines cut by a transversal line in order to solve the problem (including determining sizes of angles in a triangle, finding sizes of angles that have not been known in a triangle)" are materials of parallel lines cut by a transversal line in Level 2 (*informal deduction*) and parallelism in Level 1 (*analysis*).

Then, the mathematical concepts on the *Damar Kurung* that are included in the achievement "Learners are able to show the validity of the Pythagoras theorm and use it in solving problems (including distance between two points on the Cartecian coordinate space)" are materials about Phytagoras theorm listed in Level 2 (*informal deduction*). The next learning achievement is related to the measurement element of Phase D. It can be described as follows.

> "At the end of Phase D, learrners are able to describe the way to determine areas of circles and solve related problems. They are also expected to be able to describe the way to determine surfaces and volumes of space shapes (prism, tube, ball, paramyd, and cone) and complete related problems. Then they are expected to be able to describe the influences of changes proportionally from flat shapes and space shapes towards the measurement of lengths, angl sizes, areas, and/or volumes" (Kemdikbud, 2022).

The mathematical concepts on the *Damar Kurung* that can be included in the achievements of "Learners are ble to describe the way to determine the area and volume of space shapes (prism, tube, ball, paramyd, and cone) and related problems" are materials of surface areas and cube volumes that can be found in Level 2 (*informal deduction*). Then, the mathematical concepts on the *Damar Kurung* that can be included in the achievements "Learners are able to describe the influences of changes proportionally from flat shapes and space shapes towards the measurement of lengths, angle sizes, areas, and/or volumes" are materials concerning side diagonals, lengths of space diagonals found in Level 3 (*deduction)* and the materials related to distances of points to points, distances of points lines, distances of points to spaces, distances among lines, and distances among spaces are in Level 4 (*rigor*).

Then, what becomes a question at this time is how the implementations of the learning processes related to the classifications of the materials and learning acvievements, as described above, are realized? It is then necessary to present examples of learning activities and their relations to the van Hiele's levels of geometric thinking abilities. The material that is chosen as an example is that which is related to parallel lines cut by a transversal line with Level 2 (*informal deduction*) of the geometrical thinking abilities. The instructional process is conducted by using the scientific approach with the time allotment of 2×40 minutes. According to Kemdikbud (2017), the syntax or steps in the instructional process using the scientific approach are observing, questioning, information gathering/experimenting, associating, and communicating.

In the observing phase, the learning activity can be interpreted as reading, listening to, or observing the phenomena (involving use of the senses). In the context of learning with the materials parallel lines cut by a transversal line, this scheme can be realized by asking the students to observe what happens to the relations of the angles that are formed by the two parallel lines cut by a transversal line. This observation activity can become the starting point in directing the students to achieve the geometrical thinking ability of Level 2. This is considering that in Level 2 (*informal deduction*), learners are expected to be able to find relstionship between one object and another based on the characteristics and elements of the geometric shapes. Some learning results expected from the observation phase are, for example, accuracy, discipline (in time), and patience in looking at a context.

Then, during the questioning phase, questioning processes can be carried out in the activities of discussion or group work to build students' factual, conceptual, or procedural knowledge about a law or theory; this leading the students to practice metacognition. In presenting the materials concerning parallel lines cut by a transversal line, the teacher can present a statement that will stimulate the students to ask the teacher questions about the validity of the statement. An alternative technique can be taken in which the teacher gives a statement where there are pairs of angles with the same size formed by the the crossing between two parallel lines with a transversal line. It is expected that students will be interested and become curious and then are challenged to ask questions or make statements. From their curiosity, students may ask themselves such questions as which two angles will have the same size. From this process, learning outcomes can be obtained that will be able to develop students' creativity, curiosity, and critical thinking.

After passing the questioning phase, students will continue to the third in which they collect information or conduct experimentation. There are many kinds of activities that students can do such as reading, observing activities, events, or objects, obtaining information, working on the data, and up to reporting results in the form of writing, spoken recount, or pictures. In finding the answer to which two angles will have the same size, measurement activities can be conducted. Using protactors to measure the angles has a positive impact that it will improve students' skills in working with mathematics learning media.

After obtaining the data about angle sizes, and then work with the data, students can analyze the data in the learning phase of associating. Activities that can be done in this associating phase can be calcu;ating numbers, grouping data items, making data categories, predicting/estimating results, making conclusion, verifying by looking at patterns and interrelations among patterns and items, and conducting induction or deduction. This phase of associating is actually the core of the scientific approach to the instructional processes. A lot of learning outcomes are available for the students to capture. For example, in addition to finding which two angles have the same size, students can show the nature of the relation between the angles according to their categories or kinds of pairs. Another point is looking at the relation between the straight corners and opposing corners in the triangle. By all these elaborations, students are expected to gain improvement in their thinking abilities and, thus, elevating their Van Hiele's Levels of thinking abilities.

The last learning phase is communicating where students present the results of the conceptualization. This is best done by publishing the results of their efforts in working out their knowledge, skills, and competencies in the form of a written report, spoken account, pictures, graphs, diagrams, and so on. The students are expected to be able to recount the process of the work systematically orderly from the beginning phases of observing and questioning to the closing phase of concluding. At this stage, it will be advisable for the teacher to give confirmation at the achievements of the students and correct possible mistakes or misunderstanding of concepts. Finally, it is also important for the teacher to give appreciations for having worked hard in the learning processes and stimulations and motivations for better work in the coming classes.

In the implementation, in the actuality, the instructional activities in the learning-teaching process are not to be run in a rigid manner. On the contrary, the teacher has the flexibility to focus on certain learning activities that suit the competencies that the learners are supposed to achieve. In this case, the teacher can negotiate which level of the geometrical thinking abilities are prioritized in accordance with which learning outcomes are to be developed at a particular place or time.

CONCLUSION

Damar Kurung is a craftwork specific to Gresik Regency and has become an asset of the local culture of the regency. The lantern is made and used to enliven the situation of the Ramadhan undertaking during the fasting month and diversion for the Moslems in awaiting for the coming of the *Tarawih* evening prayers. Education wise, however, from the process of the making up to the use in the Ramadhan evening, *Damar Kurung* offers many phenomena and activities that can be identified and being used for mathematical objects in education and learning. More specifically, the mathematical elements in the *Damar Kurung* can be used to develop the five levels of learners' geometrical thinking abilities with specific characters of achievements for each level.

Mathematical concepts ingrained in the *Damar Kurung* phenomena can be identified as having the Level 0 of the geometrical thinking abilities, flat shapes of triangles and squares; Level 1 of side diagonals and space diagonals, and rotational symmetries of squares and rectangles, and parallelism; Level 2 of parallel lines cut by transversal lines, Phytagoras theorm, and surface areas and volumes; Level 3 of lengths of side diagonals and space diagonals; and Level 4 of distances of points, lines, and spaces. These levels of geometrical thinking abilities can correspond to the the learning outcomes prescribed for the Phase D of the geometric elements and assessments in the instructional processes as stipulated by the National Curriculum in the national education. As for the presentational aspect, the scientific approach of instruction can be adopted as one of the methods of mathematics learning in the class. As a starting point, in the observation phase, learners are directed to achieve the geometric thinking abilities of

Level 0 (*visualization*) up to Level 1 (*analysis*);. the questioning phase for Level 2 (*informal deduction*); phase 3 for experimenting and association; and phase 4 for making conclusion and communicating.

By use of the scientific approach to instrucction, learners are expected to nurture their curiosity and motivation in learning, work with their learning assignments in the environments of their local cultures and habits, and develop their levels of geometric thinking abilities as designed in the curriculum. Finally, as important as the other instructional characteristics of the scientific learning method, the teacher has the wisdom of freedom to undertake changes and modifications of the learning-teaching activities to be suited with the background needs and demands of the learners in their specific conditions and situations.

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