Ethnomathematics as an Exploration of Cultural Mathematical Concepts in Traditional Indonesian Engklek Games

ABSTRACT

Culture and mathematics are a unified whole. This can be seen from the culture in Indonesia, which is very diverse, ranging from traditional houses, traditional ceremonies, traditional clothes, traditional musical instruments, traditional games, regional dances, folk songs, places of worship, museums, inscriptions, temples, etc. Basically, contain mathematical concepts. The relationship between mathematics and culture is called ethnomathematics. So that this study aims to explore the mathematical concepts that exist in the culture of Indonesia, one of which is the traditional engklek game. The method in this study is a qualitative research method with an ethnographic approach. The method is done by the method of observation and documentation. The results showed mathematical concepts in engklek patterns, game rules, and gaco. The mathematical concepts in the game are the concept of two-dimensional geometry, numerators, calculations, and probability.

Keywords: Mathematics, Ethnomatematics, Two-dimensional geometry, Numerator, Calculation, Probability

1. INTRODUCTION

[According to Ruseffendi, mathematics is the science of organized structure; mathematics discusses facts and relationships and discusses space and form [1]. It can be seen that mathematics is closely related to human life and is needed in various human activities, and is even reflected in the human environment [2]. Without us realizing it, every activity and our environment is related to mathematics such as agricultural activities (measurement of land area, forecasting harvest time, measuring the amount of water for watering, calculating the amount of harvest), buying and selling activities (calculating profits and losses, calculating the weight of goods, calculating capital , calculating price discounts, calculating refunds), batik activities (determining the dimensions of patterns or motifs so that they are the same), regional arts (counting movements, determining sequence patterns, measuring the balance of locations), building architecture (there are geometric shapes, scales , calculation of building area, costs, measurements and angles), traditional games (containing activities of measurement, calculation and mathematical analysis) [3][4][5][6][7][8][9]. These activities prove that mathematics is closely related to everyday human life and can be used in solving existing problems. [10] According to De Corte (2004), mathematics is a problem-solving concept based on real-life problems.

The cultural results that we see involving various types of two-dimensional geometry and spatial shapes can be found in buildings such as mosques, churches, temples, temples, pagodas, traditional houses, and other forms of buildings; when viewed in these buildings, they contain mathematical concepts, such as wake-up flat (square, circle, rectangle, triangle), and wake-up space (cube, block, ball, tube, cone, prism). Patterns on buildings also use the mathematical concept of two-dimensional geometry, such as kites, rhombuses,

trapezoids, pyramids, and other shapes. From this, the concept of mathematics is formed, which is closely related to society and is a manifestation of human activity within the community, so it can be stated that mathematics has become part of the culture [11] and according to Bishop (1994) also said that mathematics is a form of culture that includes aspects of people's lives. And according to Pinxten (1994) states that, in essence, mathematics is part of a symbolic technology that is closely related to cultural activities. [12] [11]. This is in line with Barton, Orton, & Frobisher's opinion that mathematics is part of human culture [13].

Methods, ideas, and mathematical techniques that are developed based on a culture's views and ways of thinking are called ethnomathematics, first discovered by D'Ambrosio, a Brazilian mathematician [14]. Ethnomathematics is a bridge between mathematics and the culture found in society. Ethnomathematics is a style, art, and method of understanding, analyzing, measuring, calculating, explaining, and relating mathematics and the social environment [15].

In Indonesia, ethnomathematics began to enter as part of mathematics education, namely in 2013 by Karnilah; this started from a cultural community that did not occupy non-formal education but had implemented and developed mathematics based on activities and problems of daily life [15]. Over time, the development of research related to ethnomathematics has begun to increase; this can be seen from the various types of research conducted from multiple cultures in Indonesia. The studies conducted examining ethnomathematics in mathematical concepts are the Panjalin Traditional House [16], Rajapolah Woven Craftsmen Tasikmalaya Regency [17], Muaro Jambi Temple [18], the Great Mosque in Yogyakarta [19], elements of Javanese culture [7], Ancient wells of Kaliwadas Village Cirebon [20], Houses and Traditional Musical Instruments of Biak-Papua Culture [21], Tradition of Measurement of the Sasak Tribe Community [22] [23], Indigenous People (SAD) Batanghari Regency, Jambi Province [24], adipurwo batik [25] Teak Joglo House [26], Fort Marlborough [27], Yogyakarta Batik [28], Cassava Leaf Painting Batik at the Daweea Batik Production House [29], the Empat Lawang Turbid Air Pasemah Tribe [30], Thelas Keta traditional events for the noemuti community [31], Minangkabau Gadang House, West Sumatra [32] [33]. This is influenced by the many and varied cultures in Indonesia, from Sabang to Merauke, thus attracting the interest of researchers and teachers to study ethnomathematics in various cultures in Indonesia.

In addition to culture related to mathematical concepts such as buildings and cloth motifs from an area, traditional Indonesian games are also part of the culture preserved in Indonesia. Classic games originate from the ancestors of the Indonesian nation in a diverse community environment, where each region has its traditional games. Research on ethnomathematics in Indonesian traditional games has also become the center of attention of researchers, namely research on classic Indonesian games, namely Children's Traditional Games in the Traditional Density Area of Central Koto Sungaipuh City, Jambi Province [34], Guessing Game of Tebak-tebak buah manggis [12] , Dengklaq Games [35], Traditional Urang Banjar Games [36], Marbles Games [37][38], Congklak Games [39][40], Kempreng Traditional Games [41], Makassar traditional children's games, namely dende', foreign, cangke', and gebok [42], Lampung Province Traditional Games [43], Games Setatak [44], Cangkringan Traditional Games [45], Cenge-Cenge Games [46], Odd Javanese Traditional Games [4]. In traditional games, the tools used come from around us, which are cheap and simple. Classic games were in great demand by children in the past, but they did not understand that traditional games were related to mathematical concepts, starting from the rules of the game and the tools used to the patterns/forms of the game. Research on ethnomathematics in traditional games helps preserve Indonesian culture that can be applied to school learning so that today's children, even though they are presented with

technology-based games, can recognize traditional games and understand the mathematical concepts in them.

One of the traditional games that attract attention is the engklek game because three mathematical concepts are used: the engklek pattern, gaco, and game rules. Engklek is a traditional game played by walking and jumping using one leg. In this game, children will step according to the game's rules, namely hompimpa, then throw gaco. The Gaco at the farthest or the top of the hopscotch box will win.]

2. METHODS

[The method used in this research is descriptive qualitative with an ethnographic approach [5]. According to Spradley & McCurdy (1972), Ethnography is a research method that studies, understand views of life, and describes the culture of a group of people [5]. Descriptive qualitative research is a type of research to show and obtain comprehensive and in-depth information [5]. This method was chosen because it is by the objectives of ethnomathematics, namely a way to learn to understand, do mathematics and overcome various problems in the cultural environment [10]. The ethnographic stages in this study are as follows: observation and documentation regarding the pattern of crotchets, game rules, and gaco used to be conceptualized according to mathematics.]

3. RESULTS AND DISCUSSION

3.1 Results

[Based on the results of observations and documentation, research on the traditional engklek game has mathematical concepts. The mathematical concepts are in the engklek pattern, the game rules, and the gaco engklek. In this study, the engklek pattern focuses on three types of plots, namely house patterns, plane patterns, and people patterns, where the engklek pattern is related to the mathematical concept of two-dimensional geometry because patterns are usually drawn on a flat surface such as fields, terraces, roads in front of houses and places other. The game rules follow the hompimpa concept, where the winner will start first; in this case, the mathematical concept applied to opportunities is a permutation (where players move with attention to the hompimpa order). The gaco used in this game takes various forms according to those obtained from surrounding objects, such as ceramic shards, stones, coins, and other two-dimensional geometry from mathematical concepts. In the following, we will discuss further the things that are the focus of this research.

a. Engklek Pattern

   Based on the observations and research results, the grid patterns in the traditional Indonesian engklek game have mathematical concepts, namely rectangles, circles, squares, trapezoids, reflections, cube nets, counters, and calculations. An illustration of a flat wake on the engklek case pattern can be seen in the following figure 1-3. Based on the illustration above, with three types of engklek patterns, namely image 1 of the plane pattern, image 2 of the house pattern, and image 3 of the people pattern. Figure 1 shows the mathematical concept of two-dimensional geometry, namely rectangles, and squares. Figure 2 shows the mathematical concepts of two-dimensional geometry, semicircles, rectangles, and squares. Figure 3 shows the mathematical concepts of two-dimensional geometry, circles, squares, rectangles, and trapezoids. The engklek grid pattern also has the property of reflection (Reflection). This can be shown from its symmetrical shape and can divide into twoparts, namely the right and left sides, which are equal in size. Reflection illustration can be seen in the following figure 4-6.

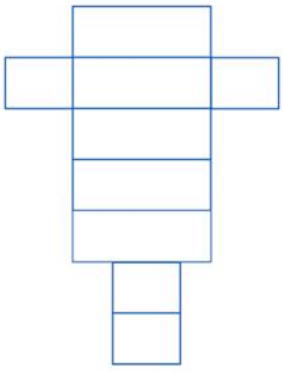

Fig. 1. The Plane Pattern

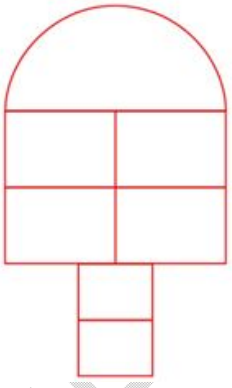

Fig. 2. The House Pattern

Fig. 3. The People Pattern

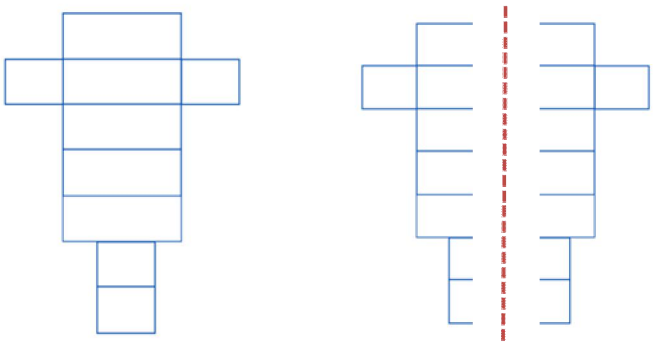

Fig. 4. Illustration Reflection On The Plane Pattern

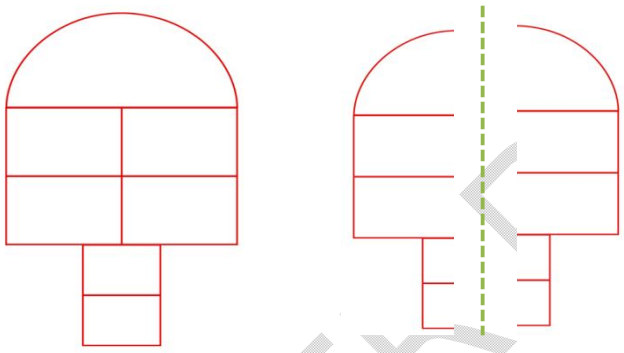

Fig. 5. Illustration Reflection On The House Pattern

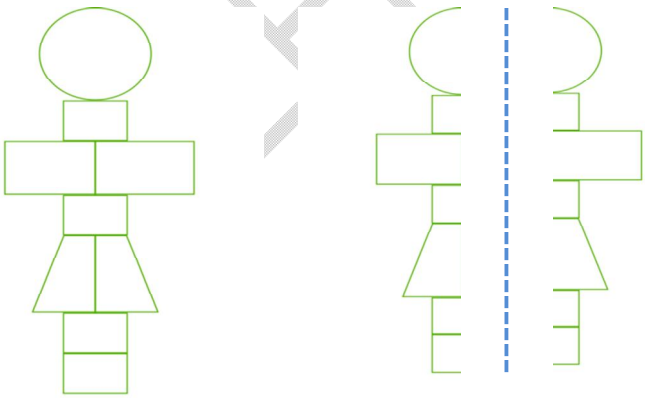

Fig. 6. Illustration Reflection On The People Pattern

In addition, the shape of the field grid pattern is a net shape. This can be seen in the illustration of Figure 7, which shows the shape of the beam net.

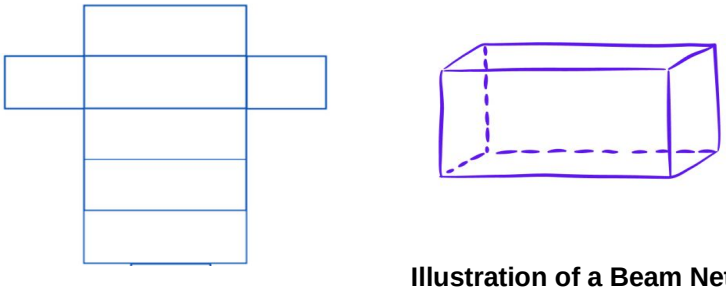

Fig. 7. Illustration of a Beam Net on a Plane

pattern

The crotch tile pattern also has a mathematical concept in quantifier and calculation; in Figure 1, the square grid pattern is formed from four squares and five rectangles. In figure 2, the house pattern is constructed from two yards, four rectangles, and one semicircle. In the picture, the three-person square patterns are built from one circle, four squares, two rectangles, and two trapezoids. The sequence for the numerator can be seen in the following illustration:

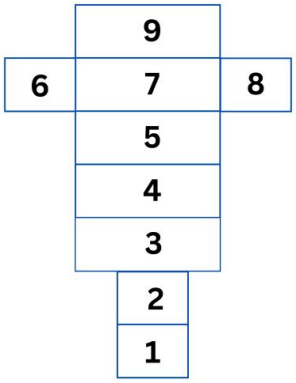

Fig. 8. The Numerator Of The Plane Pattern

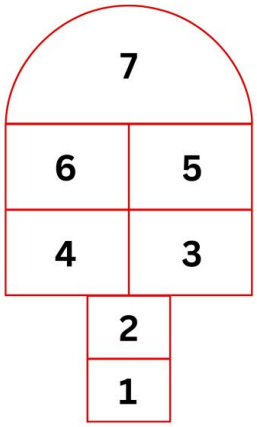

Fig. 9. The Numerator Of The House Pattern

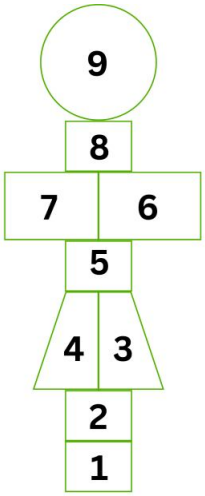

Fig. 10. The numerator of the People pattern

In the illustration of Figure 8, the plane grid pattern shows the numerator 1 to 9. In Figure 9, the house tile pattern shows the numerator 1 to 7, and Figure 10 indicates the numerator 1 to 9.

b. Rules of the game

The rules in traditional engklekt games are based on observations showing a mathematical concept, namely, opportunity, where the players will hompimpa with the first chance to play is the one who wins first (it's different when hompimpa) and so on until there are two players left to determine the final order of doing a suit. In deciding the player using the concept of opportunity, every player has the same opportunity to play. The concept of opportunity in traditional engklekt games is the permutation method. Each player gets the same opportunity to play by paying attention to the order according to the hompimpa and the suit made. As an illustration, as follows: suppose the players in a traditional hopscotch game consist of six people (A, B, C, D, E, F) with the order of first, second, third, fourth, fifth, and sixth according to the hompimpa and suit results. So that with the permutation formula, the pattern of the order of play can be known as follows:

$$P^{6}_{6} = \frac{6!}{(6-6)!} = 6! = 720$$

There are 720 patterns of playing sequences from the four children

c. Gaco on engklek

Gaco in the traditional engklek game has various forms because it comes from objects around it, such as stones, ceramic shards, coins, cement shards, and so on. based on observations, it can be seen that the shape of the gaco resembles a flat shape such as a triangle, round, trapezoidal, ellipse (oval) and rectangle. The illustration of a flat wake on gaco can be seen as follows:

Fig. 11. The Form Of The Gaco Used In The Engklek Game

3.2 Discussion

Traditional games in Indonesia have various types of games according to regions in Indonesia such as Jangklet (Engklek), Jatengan (Beker Ball), Ampar-ampar Pisang, Rope Jumping, Playing Sand, Senidanan (Petak Umpet),Marbles, Congkak and traditional games others scattered in every region of Indonesia with different names depending on each area. The engklek game is one of the traditional games that contain many mathematical concepts in each game, starting from the pattern of the engklek tiles, the rules of the game and to the gaco used. Exploration of the mathematical concepts found in traditional engklek games shows that there is a connection between mathematical concepts and culture, namely the concepts of quantifier, calculation, two-dimensional geometry, cube nets, and opportunities which are in line with the research conducted where these mathematical concepts are the first point that needs to be understood by children, starting from knowing numbers to attending school.

Based on the results of observations, it was found that the shape of the flat shape (geometry) in this study is ethnomathematics as a form of exploring the concept of cultural mathematics in the traditional engklek game, namely in a grid pattern consisting of 3 etching shapes, namely plane maps, house plots and people plots which show a flat shape shape. Namely square, rectangle, square, circle, and trapezoid, the gaco used in the traditional engklekt game also contains two-dimensional geometry, namely triangles, circles, ellipses, trapezoids and rectangles, in line with research on ethnomathematics of other cultures in Indonesia, for example in several Rajapolah woven crafts contain mathematical elements, one of which is the use of the tessellation or tiling principle, geometric shapes that can tessellate for example squares, triangles, regular pentagons, regular hexagons and can also be curves [17], the Muaro Jambi Temple building consists on sus ancient brickwork in square and rectangular shapes on the walls of Gumpung Temple, the arrangement of bricks at the entrance to Gumpung and Umpak Batu Temples so that the mathematical concept in the form of geometry is also found in Muaro Jambi Temple [18], several parts of the grand mosque in Yogyakarta have aspects Mathematically, namely the carvings (ornaments), the pavilion, the roof of the mosque, the kentongan (drum), parts of the floor and the gate related to the concept of geometry including flat buildings and the spatial structure of the Great Mosque in Yogyakarta [19], traditional Biak-Papua cultural houses have a mathematical concept, namely the roof shape of rum som (rectangular and triangular shapes, sram mankubui roofs (trapezoidal and triangular), tifa (conical) [21], in the Thelas Keta traditional event for the noemuti community there are several mathematical concepts, namely circles, rhombuses, and rectangles [31], the shape of the house building is at Minangkabau there is a mathematical concept, namely in two-dimensional geometry (geometry), namely squares, rectangles, trapezoids, triangles, isosceles triangles, equilateral triangles, pentagons, circles and rhombuses [32] [33].

4. CONCLUSION

Various forms in the traditional engklek game have ethnomathematics values. The pattern and gaco contain mathematical concepts: two-dimensional geometry such as squares, rectangles, trapezoids, circles, and ellipses. The game's rules include mathematical concepts, namely probability for permutation material. In addition to traditional engklek, games include mathematical concepts, namely numerators, calculations, and cube nets (plane grid patterns). This proves that mathematics and culture have a close relationship that can enrich knowledge and provide insight into understanding mathematical concepts and the surrounding environment.

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