Ethnomathematics: Design mathematics learning at secondary schools by using the traditional game of Melayu Riau

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Abstract. Riau Province has been committed to become the center of Malay language and culture in 2020. Various efforts need to be made to introduce the Cultural Heritage both inside and outside the province. This research supports the government's commitment by designing mathematics learning using local culture. This research, design mathematics learning at the Secondary School using the traditional game namely Rimau, Ligu and Guli. The findings will be used in mathematics learning to introduce culture while bringing mathematics closer to student life. This study is a research and development with the Four-D approach. Game exploration is done at Define Stage, Instructional Design is done at the design stage, Learning material is created at the development stage. The Instructional design is disseminated into teachers and students of Secondary Schools. Data collection is done through documentation studies and interviews. The Game exploration resulted in the use of these games for various mathematical concepts of algebra, Geometry, and statistics for mathematics learning in secondary schools. Based on FGD with the users can be concluded this Mathematics Learning Design help teachers in delivering relevant topics and recommended to be used by secondary schools teachers.

Keywords: Ethnomatematics, Secondary School, Traditional Game, Melayu Riau

1. Introduction
Riau Province has declared itself committed to becoming the center of Malay culture in 2020. This policy certainly has consequences for various preparations for implementation. So far the tourism office has been pursuing various activities by enlarging cultural activities, exploring cultural-based tourism objects. Riau's desire to be the center of Malay culture in Southeast Asia has been outlined in Regional Regulation No. 36 of 2001. The Riau provincial government has established itself as the center of Malay culture, so various efforts have been made to introduce various aspects of Malay culture. Support has also been provided by the central government through Law No. 5 of 2017 concerning the promotion of Culture. In this law article 24 states that this culture must be passed on to the next generation. In articles 32 and 33 it is stated that cultural objects need to be used to build the character of the nation and the need for efforts to internationalize cultural values.

Various efforts have been programmed by local governments, including registering cultural heritage to UNESCO such as pantun and silat. The acceleration of the internalization of cultural values is still constrained by human resources, the government is well aware of the need for human resources
who understand the culture. To encourage young people to know the culture, one of the programs carried out is a scientific work competition on Malay culture.

Until now the efforts made have not been structured through formal education, although in general the curriculum also mandates the use of local wisdom in learning. Tambak states that only 18.9% of Madrasas in Riau Province integrate cultural Malay into school learning [1]. This integration is done through extracurricular, local content and core learning curriculum. In general this is of course not sufficient to pursue a target that is less than two years away. Researchers see that there needs to be a greater effort to integrate culture through schools more specifically through learning so students do not feel burdened with new lessons. One of the efforts made is to integrate the introduction of culture through mathematics learning. Hasanuddin stated that various cultures such as carving, fashion, literary arts can be part of ethnomathematics learning[2]. Through the integration of mathematical and cultural content in education can foster the ability and creativity of students to develop superior cultural heritage according to the present context by using the basis of mathematical creative thinking skills. Creative thinking developed through the integration of mathematics and culture is characterized by logical, rational, imaginative, accompanied by a sense of aesthetics[3]. Mathematics can be given as a cultural response to the needs of students by making connections between cultural and mathematical backgrounds. Mathematics can also be presented as a cultural product developed from various activities. Mathematics is more relevant for students because the culture is assumed to have a mathematical response to mathematical material. Ethnomathematics uses the cultural experience as a means to make mathematics more meaningful and provides insight for students about the mathematical knowledge that exists in their social and cultural environment[4].

Based on the description above, there is a reciprocal relationship between mathematics and culture. As a cultural product, mathematics can be taught and learned through and in culture. Mathematics has an important role to develop existing culture into a more advanced culture. Ethnomathematics is not only done to investigate facts, concepts, and mathematical practices that exist in a particular culture of society, but uses the results of cultural investigations to teach mathematics as well as cultural values to students.

The Provincial Government of Riau through Governor Regulation No. 72 of 2015 affirms that the subjects of local content imposed in all schools in Riau are Local Content of Riau Malay Culture. This Local Content contains Riau's Malay culture which includes history, value systems, patterned habits or traditions and other lessons. Following up on Governor Regulation No. 72 of 2015, in 2018 the Riau Provincial Education Agency together with the Malay Customary Institution has launched the Riau Malay Culture (BMR) curriculum for elementary, middle and high school levels. The Malay Culture Book has been published to support the implementation of this local content curriculum.

This Regional Regulation is in line with the policies in the 2013 Curriculum. Rules and guidelines for the application of local content have been mentioned in the Minister of Education Regulation No. 79 of 2014. In the regulation it is explained that local content is a study material or subject in education units containing content and learning processes about local potential and uniqueness intended to shape students' understanding of excellence and wisdom in the area where they live.

Nowadays folk games are being abandoned along with technological developments. In fact, traditional games contain cultural values that are essentially an ancestral heritage that must be preserved. An approach that can be used to explain the reality of the relationship between environmental culture and mathematics when teaching is ethnomathematics. Furthermore, ethnomathematics is one form of mathematical learning strategy that links the wisdom of local culture in mathematics learning.

Through ethnomathematics mathematical concepts can be developed in cultural practices. In Malay society Malay decoration is a cultural element originating from Riau and developing in the Riau community [5]. Ethnomathematics is a form of learning approach that links local wisdom in mathematics learning. Through ethnomathematics mathematical concepts can be studied in cultural practices. With ethnomathematics students will better understand how their culture is related to mathematics, and educators can instill noble values of national culture that have an impact on
character education[6]. The perspective of the society that mathematics is a subject has changed into mathematics as part of life for example through woven crafts [7]. In this woven craft is shown the need to measure and sort the numbers in compiling the motif to be made. This approach can make students or the public better understand how their culture relates to mathematics.

In this research, mathematical concepts and thoughts will be explored in some folk games so that they can be used in mathematics learning. Riau Malays have a variety of games, some of these games have similarities to games found in other areas with different names, but there are a number of typical games that become the grounds of Riau's Malay region. In this study, these specific game were used, namely the game Rimau, Ligu and Guli. This game was chosen because of its nearly extinct in the community.

2. Research Method
The research carried out is qualitative research that begins with digging information directly from the parties concerned about the games will be used in this research. In the initial stage, a literature study was conducted to obtain information about traditional Malay folk games. Based on these data interviews were conducted with the local community to obtain detailed information about the game. The information included the media use for the game and the rule in doing the game. The information that has been obtained is used to learn how to do the game.

The next stage is to do an analysis of the games that have been identified. At this stage, each game is analyzed to find the mathematical thoughts contained in it. An analysis is carried out on the game and the game steps. The results of the identification of mathematical thinking in the game will be the basis of curriculum analysis so that relevant subject matter is obtained to be developed using the game. Learning activities are taken from the games’ equipment, game rules, and game steps. By conducting learning activities students will get mathematical concepts and indirectly also be introduced to the chosen traditional game.

3. Result and Discussion
Based on literature review and interviews conducted by the author to several communities, information was obtained that there were three folk games used for learning activities, namely Ligu, Guli and Rimau games. In the next stage, the author obtained information about the analysis and identification of folk games, equipment and steps in carrying out folk games. The following will be presented about the analysis and identification of steps in folk games and their use in mathematical learning activities.

3.1. The Game of Ligu
The game of LIGU is found in several areas such as Tembilahan Regency, Indragiri Hilir and Kampar Regencies, in the Kampar area this game is known as Singki. Game is not related to customs, and can be played by any community within 3 hours. This game uses a coconut shell which is wasted from making copra. The game grew from a long time ago and was passed down from generation to generation without knowing exactly when it was discovered. Ligu games are played by 4-12 teenagers within a team. This game requires dexterity and energy to throw the shell with a piece of wood, so it is not played by girls. The game of ligu is played on fairly flat land and is not overgrown with grass about 4x1depa. The game tool consists of a stick made of bamboo along one hasta. Sticks are used for throwing shell beaters. Other equipment is Ligu made from young coconut shell. Ligu is made in the form of diamonds, flowers and leaves with the size of the palm width [8].

Leaning Activities in mathematics class using the game of Ligu is as follows:
Competencies
Class VII
3.4 Explain the set, subsets, set of universes, empty sets, complement sets, and perform binary operations on sets using contextual problems.
4.4 Resolving contextual problems relating to sets, subsets, sets of universes, empty sets, complement sets, and binary operations on sets.

Learning Activities: Know the Concept of the Set
1. Students are given one ligu.
2. Learners are divided into two groups by bouncing the turns alternately.
3. One student writes the results of the joining of the ligu of his friend (on his back or face down).
4. Students classify the names of students in each group
5. The teacher states that there are two sets of ligu groups, namely the set of recumbent ligu and the set of ligu facedown.
6. Students discuss to conclude the definition of the set.

Competencies
3.7 Explain the ratio of two quantities (the units are the same and different).
4.7 Resolve problems related to two-dimensional ratios (units of equal and different).

Learning Activities: Determine the Ratio of Two Magnitude with the Same Unit
1. Students are taken into a schoolyard and are given a 20 m long rope.
2. Students draw the play area.

![Area of Ligu Game](image1)

**Figure 1.** Area of Ligu Game

3. Learners use the concept of comparison to determine the 'straight-line' as long as 15 m on the playing field using a rope.

Class VIII Competencies
3.11 Explain empirical and theoretical probability for an event from an experiment.
4.11 Resolve problems related to empirical and theoretical probability for an event from an experiment.

Learning Activities: Determine Theoretical probability students are divided into two large groups.
1. Each group has one person as chairman.
2. To start the game, the group leader performs ligu toss to determine who first plays.
3. Before joining the floors, the teacher stated that the Probability of the two groups to first play was 1/2.
4. Group members observe the ligu toss made by the group leader.
5. Students discuss theoretical probability and ways of determining the magnitude of opportunities.

Class IX Competencies
3.6 Explain and determine congruence between of two-dimensional figures.
4.6 Resolving problems related to congruence between of two-dimensional figures

Learning Media to Identifies Congruency Two dimensional figures
1. Learners observe some ligu
2. The teacher shows two congruent ligu.
3. Students discuss to determine the characteristics of congruency of two-dimensional figures.

3.2. The Game of Rimau
Rimau is a regional term used for tigers. The term rimau used in this game with the other person playing is a goat. This game is a folk game that mimics a chess game played by Riau nobles in the XIII Century. The Rimau game mimics a chess game by making scratches on the board so that it resembles a chessboard. Small shells or stones found around the beach are used as chess pieces. In this game, one rimau and 24 goats were used. This game is usually played by two teenage boys. The equipment used is a rimau board which is also called a rimau board made from a piece of wood board or on a bench that is scratched with a knife or written in pencil. The rimau board is usually about 40x30 cm in size. Other equipment is 24 stone seeds or shells that will symbolize a goat and a bigger and better stone to symbolize the robustness of the rimau. Mathematics Learning Activities using the game of Rimau can be seen as bellows.

Class VII Competencies
3.10 Analyze relationships between angles as a result of two parallel lines cut by a transverse line
4.10 Resolves problems related to relationships between angles as a result of two parallel lines cut by a transverse line

Learning Activities: Determine Line Position
1. Students observe the rimau board (it can also be with the help of images through the LCD projector).

2. The teacher marks two lines of 'dark path' in red on the board and states that the two lines are parallel.
3. Students identify the characteristics of two parallel lines.
4. The teacher marks one of the diagonals in green and declares diagonally bypassing the tapak lapan line.
5. Students write down the characteristics of two intersecting lines.
6. Students show parallel lines and intersecting lines (perpendicular or not perpendicular) on the board.

Class VII
Competencies
3.11 Associate the perimeter and area formulas for different types of squares (square, rectangle, diagonal, rectangular, trapezoidal, and kite) and triangles.
4.11 Resolve contextual problems relating to the area and circumference of rectangles (squares, rectangles, divisions of squares, margins, trapezoids and kites) and triangles.

Learning Activities: Identified Characteristics of the rectangle
1. Students observe the game board (also with the help of images through an LCD projector or picture board on the LKPD).

![Image](Figure 4. Using Rimau Game Area to show perimeter and area of squares)

2. The teacher marks the game board area by closing with the blue and red and states that the area formed is square.
3. By using a board (picture board), students identify the properties of a square from the side, vertex and diagonal aspects.

Class VIII
3.6 Explain and prove Pythagorean and triple Pythagorean theorems.
4.6 Resolving problems related to Pythagorean and Pythagorean theorems.

Learning Activities: Identify Pythagoras Theorem
1. Learners observe a board (also with the help of images through an LCD projector or picture board on an LKPD).

![Image](Figure 5. Using Rimau Game Area to show Phytagoras theorem)
2. Learners show figure which is a right triangle
3. Students identify the properties of a right triangle

Class VIII
Competencies
3.11 Explain empirical and theoretical probability for the occurrence of an experiment.
4.11 Resolve problems related to empirical and theoretical probability in the event of an experiment.

Learning Activity: Determine the probability of Theoretical probability
1. Learners are divided into two large groups, each of which serves as 'rimau' and 'kambing'.
2. Each group has one person as chairman.
3. To start the game, the group leader conducts a suit to determine who first played.
4. The group leader is asked to make 30 suits and the group members record suit results and make them in a table.

5. Students answer questions of:
   a. The possibilities for "rimau" to play first.
   b. The possibilities for 'kambing' to play first.
   c. The possibilities for both
6. Students make an example of the possibilities that occur, such as:
   a. \( n (S) \) = a number of possible results
   b. \( n (A) \) = the number of possibilities "rimau" first played
   c. \( n (B) \) = the number of possibilities for 'kambing' to play first.
7. Students make a comparison of \( n (A) \) to \( n (S) \) and \( n (B) \) to \( n (S) \) so that they understand the theoretical opportunity concepts.

Class IX
Competencies
3.5 Explain geometry transformations (reflection, translation, rotation, and dilation) that are associated with contextual problems
4.5 Resolving contextual problems related to geometry transformation (reflection, translation, rotation, and dilation).

Learning Activities: Determining Shadows as Reflection Results
1. Learners observe a game board (also with the help of images through an LCD projector or picture board on an LKPD).
Figure 7. Using the Rimau Game area for mirroring object

2. The teacher marks one line in yellow and states that the yellow line is a mirror.
3. Learners put red beans at one point.
4. Other students determine the shadow of the seed by using a yellow line as a mirror.
5. The shadow of the sea seed is assumed to be blue.

Class IX Competencies
3.6 Explain and determine congruence and similarity between two-dimensional figures.
4.6 Resolving problems related to congruence and similarity between two-dimensional figures.

Learning Activities: Identify the congruency of two-dimensional figures
1. Learners observe a game board (also with the help of images through an LCD projector or picture board on an LKPD).

Figure 8. Using Rimau Game Area to show congruency of two triangles

2. The teacher marks the 'gunung' on a blue board and states that the two mountains are examples of two congruent figures.
3. Students discuss to determine the characteristics of congruency on two triangles.

Class IX Competencies
3.5 Explain geometry transformations (reflection, translation, rotation, and dilation) that are associated with contextual problems
4.5 Resolving contextual problems related to geometry transformation (reflection, translation, rotation, and dilation).
Learning Activities: Determining Shadows as Translation Results

1. Learners observe a game board (also with the help of images through an LCD projector or picture board on an LKPD).

![Figure 9. Using the Rimau Game area to show the translation of the object](image)

2. Learners use black rimau seeds as 'rimau' and put on tengkuk.
3. Students use red seeds.
4. Learners do translation process of the red seeds to approach the rimau.
5. Each move is recorded as the number of move and the target direction.
6. Students can find out the translation by only mentioning the magnitude and direction of translation.

3.3. The Game of Guli

Guli or marbles game is a game played by boys and girls. This game is done at leisure both in the morning and evening in the shade. This game usually takes one to 2 hours. This game is usually not played during the rainy season, because this game uses holes made on the ground. This game, usually played by children who live in the lowlands settlements, coastal fisherman housing, and in the valleys of the river banks and not hilly. This is because the guli are used to play is in a round shape, and are easy to roll on the cliffs. In playing guli, children rely on each other's intelligence and skills and flick the guli with their fingers to the right target.

At first, the guli were made from pieces of wood or enough wooden terraces and rounded up by the size of chicken eggs, or from the skin of clams, large corals found on the seabed or on cliffs. After the second world war, the guli or marbles that were once made of cement with the size of a big toe, now used are smaller glass marbles.

There are two ways to do a guli game, namely Main Beraja or Main Berudung. The number of players will be determined by how to play this. Main Beraja is playing as a single-player, in a game there can be two to five people. Main Berudung is a group game, in one group consisting of two to four people. The guli game, need some equipment to play, first is one or two guys per person. The second equipment is the arena to play on a plot of land with an area of about 5x2 m. In this arena, three holes were made with a size of 2 times the size of the guli used. These three holes are called the King's hole/ upper hole, middle hole and bottom hole. The line of the cage is made with the size of the finger between the hole of the king and the middle hole. The king's hole is the center of the circle, this circle is called the cage line. The distance from one hole to another hole ranges from 12 to 20 feet of the player. The activities in learning mathematics using the game of guli is presented as follow.
Class VII
Competencies

3.8  Distinguishing comparisons of values and reversing values using data tables, graphs, and equations.

4.8  Resolve problems related to comparison of values and turn around values.

Learning Activities: Understanding and Solving the Problem
1. Learners are given two different types of guli, type I and type II
2. Learners conduct experiments using scales. The left side scales are filled with type I guli and the right side scales are filled with guli type II.
3. Students discuss to determine the number of guli on the left side and the number of guli on the right side to make the scale balanced.
4. Students write down the number of guli on each side of the scales in the table.
5. Students discuss to determine the comparison of size (radius) of guli type I and type II.
6. Students can conclude that the larger the size of the guli, the less the number of guli on one side of the scale so that the scales remain balanced.

Class VIII
Competencies

3.7  Describe the center angle, circumference, arc length, and area of the circle, and its relationship.

4.7  Resolve problems related to the center angle, perimeter angle, arc length, length of the circle, and their relationship

Learning Activities Get to Know the Circle
1. Students are taken into a school yard
2. Learners describe the area of the guli game.

3. The teacher states that there are several circular elements in the area of the guli game, such as the king’s hole is the center of the circle, the distance between the hole of the king and the middle hole is the radius.
4. Students draw a sketch of the guli game area on the worksheet.
5. Students discuss to define the circle elements.

Class VIII
Competencies

3.8  Explain the tangent of external mutuality and mutuality in two circles and how to draw it.

4.8  Solving the problems related to mutuality tangents

Learning Activities Identify Tangent Circles
1. Learners observe the picture of the guli game area (directly on the school yard / image displayed via the LCD projector or worksheet).
2. Students make a line that intersects the middle hole.

![Figure 11. Using Guli Game area to show tangen of the circle](image)

3. The teacher states that the line that intersects the middle hole is a tangent of the circle.
4. Learners experiment to determine the distance between the king hole and the middle hole, the distance between the king hole, the tangent of the circle, and the magnitude of the angle formed between the radius of the circle with tangent circles.
5. Students discuss to identify the requirements of a line that is a tangent circle.

Competencies
3.11 Describe the empirical and theoretical probability of an experiment.
4.11 Solve problems related to empirical and theoretical probability from an experiment.

Learning Activities: Determine Theoretical Probability
1. Students are divided into two groups.
2. Three of the group representatives will play guli by 'group'.
3. The other group members observe the game and record each movement and position of the guli (outside or inside the king's area).
4. Based on the position and number of guli (having their own group or an opponent), each group determines the size of the group's probability of winning the game.
5. Based on records of probability in each step of the game, students conclude the understanding of theoretical opportunities.

From the results of the design of mathematics learning activities using the game above it can be understood that the game Ligu, Rimau and Guli can also be used to embed several character values including: 1) carefully; 2) curiosity; 3) honest; 4) discipline; and 5) creative. Wahyuni, A. et al all stated that ethnomathematics is a form of learning approach that links local wisdom in mathematics learning. Through ethnomathematics mathematical concepts can be studied in cultural practices. With ethnomathematics students will better understand how their culture is related to mathematics, and educators can instill noble values of national culture that have an impact on character education[6]. Building characters through ethnomathematics has also been done by other researchers[9]. Analysis of mathematical thinking on character values in ethnomathematics above can also be identified based on geometry and arithmetic groups.[10].

The development of mathematics learning has been carried out for various topics in various cultures. To overcome the backwardness of mathematics learning in West Papua, Ubayanti et al. Have tried to integrate local culture into mathematics learning[11]. The use of Sero (traps) as a learning resource is one way to overcome the difficulties of students learning mathematics, especially for numbers and geometry.

Some studies suggest that ethnomathematics has a relationship with mathematical concepts especially in geometry groups. Various forms of introducing the basic geometry at elementary school
can be presented through the Pasedahan batik motif in the city of Pasuruan. Pasedahan Suropati batik motifs that have geometric concepts for elementary schools, of course can be used in geometry learning such as line recognition, angle recognition, and the introduction of simple two-dimensional figures.[12] The geometry concept builds spaces such as beams, sideways prisms, cylinders and half of the ellipsoidal can be found in the Gentala Arasy basin in Jambi City of Seberang. This makes the basis for using the Gentala Arasi wake model as a learning medium.

Similar research was also carried out by Fitriani, et al to show the Dayak Society, various mathematical concepts such as geometry were used in everyday life, even more complicated woven mats also used geometric concepts. Through a series of studies of various elements of Dayak culture such as oral literature, artifacts, games, culture of counting and measuring in society it has been used to develop mathematics learning in schools. [13] Sumardyono in [14] states that mathematics is sociocultural-historical, mathematics is a part of culture and born of a long historical journey in human life.

The game of Rimau is used for geometric transformation, other researcher use the process of batik found the basic concepts of mathematics such as counting, measuring, reflection, rotation, translation, to mathematical models that cover all cultural activities in the process of batik. Azra revealed the geometry concept to describe the carving of the Tongkonan traditional house. The geometry concept is part of the engravings found in Tongkonan traditional houses such as symmetry, monolithic, angular angles, diagonals, parallel lines, curved lines, squares, rectangles, circles, triangles, diamonds, kites, trapezoidal and square lines. Triangle is a geometry form found almost in all Toraja carvings is a triangle because this also illustrates their belief in worshiping three rules.[15] Ethnomathematics using Indramayu Paoman batik has been used in elementary schools. This batik motif has helped to explain the point material, straight lines, curved lines, zigzag lines, line lengths, parallel lines, angles, flat triangles and rectangles, symmetry lines and parallelograms.[16] The same topic is also used in the Rimau game.

This research also has similarity with Kuntarto research [17] that presenting the batik process in the community contain an element of mathematical critical thinking. The mathematical topics that can be found in this activity are counting, measuring, locating and designing. In addition, this batik motif can also be used to explain the material of comparative concepts, congruency, area of two-dimensional figures, concepts of reflection, translation, and rotation. Maryati and Suparman have used the process of designing Kartini kebaya as part of mathematics learning. The activity of designing kebaya Kartini has various mathematical concepts, such as angles, measurements, and integer operations.[18] The presentation of geometric transformation concepts through Discovery Learning using Lampung batik motifs has shown an increase in learning activities and student learning outcomes.[19] Furthermore, ethnomathematics research in the numbering system in Riau Malay society conducted by Noah and Dardiri shows that many activities counting in community activities related to the number of days. Calculation of the number of days found is used for the implementation of several ritual events both marriage and death or child birth.[20]

4. Conclusion
From the results of the research on ethnomathematics, it can be concluded that ethnomathematics possessed by each region has a relationship with mathematical concepts that can be integrated into learning at the elementary and secondary levels. Based on the discussion above, it is clear that ethnomathematics has an influence on learning formal mathematics class. Ethnomathematics provides contextual meaning needed for many abstract mathematical concepts. The form of community activities related to mathematics that are numerical operations is practiced and developed in the community such as how to add, reduce, measure, determine location, building design. Various types of games that are practiced by children, spoken languages, written symbols, images and physical objects are mathematical ideas that have mathematical values that can be developed in mathematics learning. In order to accommodate the role of ethnomathematics in learning, mathematics teachers need to place themselves as facilitators and place students as partners so that active participants in sharing
information are not passive recipients of information presentation. Teachers need to train and improve the ability to integrate culture into mathematics learning.

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