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Ethnomathematics in Arfak (West Papua –Indonesia): Hidden Mathematics on knot of Rumah Kaki Seribu

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This ethnomathematics article focused on the models of knot which is used in the frame of *Rumah Kaki Seribu*. The knot model itself was studied mathematically. The results of this study revealed the way Arfak tribal communities think mathematically. This article uses exploration, documentation, interview, experiments and literature studies method. The result showed that Arfak tribal communities used the characteristics of a triangle. It can be proofed by looking at their consideration of the strengths, endurance, and the stability of their Rumah Kaki Seribu.

Key word: Ethnomathematics, Hidden Mathematics, Rumah Kaki Seribu, Arfak Tribal community.

INTRODUCTION

Ethnomathematics is a mathematics science that is used by humans in their own culture (D'Ambrosio, 1989). Whether consciously or unconsciously, all of human activities in the world are done based on appropriate calculation that is suitable to the condition of the nature where they live. The research is related to ethno-mathematics such as, mathematics in patterned creation in Congo (Seaquist, 2005), Mathematics in traditional games in Nigeria (Yusuf, 2010); calendar system of Indian also has mathematics science that is similar with Mayan ethnic (Kak, 2011); African mathematics facilitates mathematical concepts (Horsthemke and Schäfer, 2007). The relation of art and symmetry of geometry in Africa (Marchis, 2009), Mathematics science in basket handicraft of muzambi in Southern Africa (Gerdes, 2011), and Mathematics science in a puzzle game in Nigeria (Shuaibu, 2014).

ethnomathematics is very effective. It can be proved by many studies, such as Orey and Rosa (2012), Muzangwa (2014), Fyhn (2009), Narayanan (2011), andAchor (2009).

Papua consists of 319 tribes and 263 local languages. Among these tribes every tribe has their own uniqueness. One of the uniqueness is the traditional houses; for example honai house, a tree house and rumah kaki seribu.

Rumah Kaki Seribu (in English: one thousand feet house) is a stage house on Arfak in Pegunungan Arfak Province of West Papua-Indonesia. This house has many poles: it is called Rumah Kaki Seribu. This house looks so unique because of these poles; it is made without using any spikes. It is assembled using ropes.

The problem of education in Arfak Tribal is students' absenteeism, shortage of teachers and school mathematics books are difficult to understand by

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Figure 1. Rumah Kaki Seribu (thousand feet house).

Associated with mathematics learning, the study of students. Students are often absent because of work in the garden or in their homes. A teacher teaches 2-3 classes at the same time. Math books are obtained from Java, making them not to reflect Arfak culture. Therefore, extracting ethnomatematics is required of Arfak tribe. Ethnomathematics can be used as teaching materials for teachers and students. The students can learn math in their culture.

This study discussed ethnomathematics of Rumah Kaki Seribu. This study focuses on the strap knot model that is used on the frame of the floor, and the frame of the walls is very strong. The knot models are studied mathematically. From the results of this study, it is revealed how the Arfak tribes think mathematically. In addition the results of this mathematical model can be used as a media in the teaching- learning process of mathematics in formal schools of Arfak tribal communities.

METHODS

The methods used in this research are exploration, documentation, interview, experiments and literature studies. Exploration and documentation is done to determine a knot forms in the floors and walls of the rumah kaki seribu. Interviews were conducted to reveal the use of knot forms. Experiment is done by making a knot that aims to identify the geometric shapes. After having the geometric shapes, then conducted the literature and analyzed the studies related to geometry. This method is hidden or frozen Geometri Thinking (Gerdes, 1986, 2003).

RESULT

The results of documentation and the observation of knot frame of rumah kaki seribu have several forms. In this discussion is presented the shape of the knot, the magnitude of movement due to the heavy load or the pull of wood tied. From the magnitude of movement it will be correlated with the reason of the usage.

The shape of the rumah kaki seribu

Figure 1 shows the picture of Rumah Kaki Seribu. The building of this house is very simple; it is made from small pieces of wood that are tied on each other by using a rope or rattan. The way to tie the wood is matched with the function of the knot itself. For the floor knot the function is to hold the floor up, while the wall knot is used to straighten the wall and smooth the walls to keep them straight.

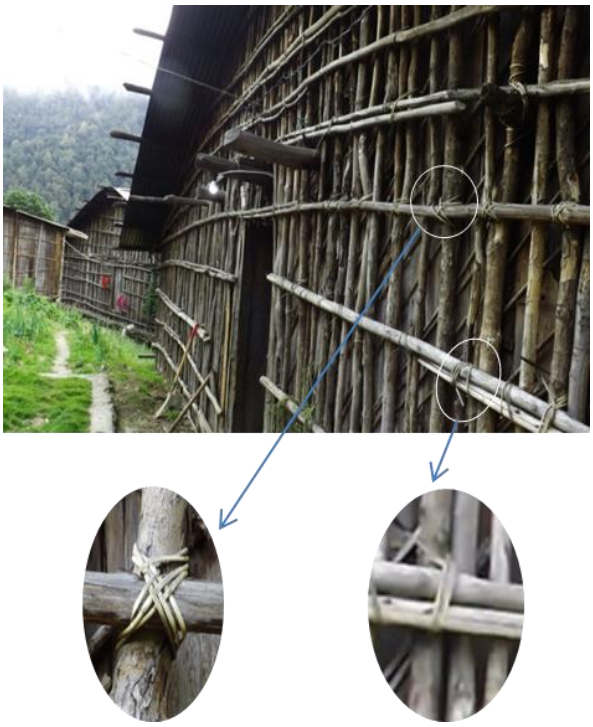

Figure 2. Wall knot frame.

Wall knot frame and floor knot frame of rumah kaki seribu.

Wall knot frame

The knot that is used in the wall framework has two types; there are primary knot and secondary knot. These two kinds of knot can be seen in Figure 2. Geometry model two knots can be seen in Figures 3 and 4.

Both types have some similarities: there are ropes that are tied to the mast in the top and bottom side in a vertical line. On the primary knot is located at point *A* and *D*. Whereas the secondary points *A* and *D* are very close and almost coincide. This knot function is to straighten the frame on the wall in order to form a flat plane. In line with the function, the framework of the wall knot will pull and hold the wood up horizontally.

Knot floor frame

The knot and the model that is used in the framework of

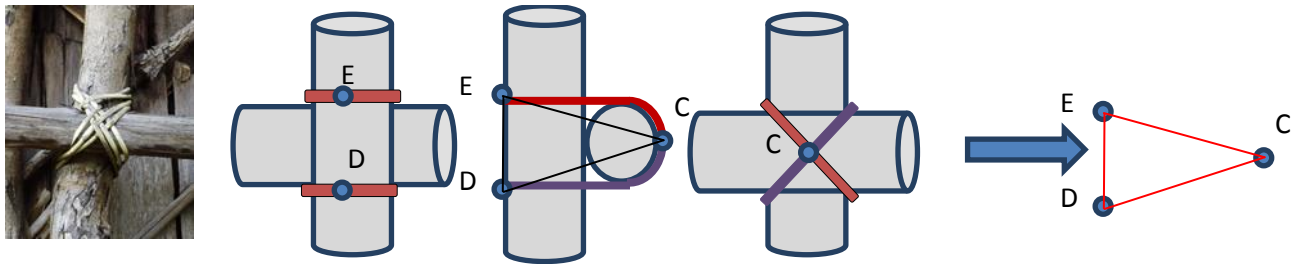

Figure 3. Primary knot and geometric models.

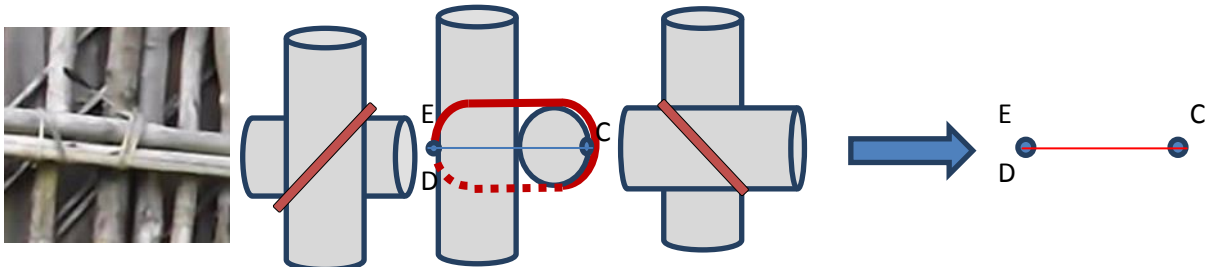

Figure 4. Secondary knot image and geometric models.

the floor can be seen in Figure 5.Take a look of the shape, the type of this knot is complicated if it is compared with node wall frame knot. The function of this knot is to pull the load up. In accordance with these functions, this knot will pull the wood up vertically.

This knot can be modeled geometrically as in Figure 5 in the right side. The differences of knot model with a wall frame are point *A* and point *D* as the fulcrum on the mast in one line vertically. Point *D* is on the outer side of the pole to the node and point *A* is located on the side of pillar of the knot. Point *A* is due to the circular bond on mast top.

DATA ANALYSIS

Analysis of wall frame

Arfak Tribe community in binding Framework of the wall uses a knot model through point *E*, *C* and *D*. Point *D* and E is the outer side of the pole and point *C* is located on the outer side of the horizontal timber. The purpose of this knot is to flatten and straighten the wall in order to form a flat surface to a vertical position. The purpose of this knot is made to withstand the pressure of the movement from point *C* to *C'* horizontally. The following will be analyzed –the movement of the knot then compared with the knot models of the floor framework through *A*, *C*, and *D (Figure 6)*.

Triangle *CEH* is an isosceles triangle where *EH = EC* as the length, the result showed the changes of rope *p.*

p = *(E'C-EC) –(C'D-CD)*
= *(E'C – EH) –(C'D-CD)*
=*HC'–(C'D-CD)*
q = *(A'C-AC) –(C'D-CD)*
= *(A'C – AI) –(C'D-CD)*
=*IC'–(C'D-CD)*

Furthermore, triangle *CAI is* an isosceles triangle where *CA = AI*.

Suppose I in $\overrightarrow{CH}$ that is in triangle *CAI'*

$\angle ACI' < \angle ECH$ (#)

$\angle CI'A = \angle AC'E + C'HI'$
➔$\angle CI'A = \angle AC'E + EHC$
➔$\angle CI'A = \angle AC'E + \angle ECH$
➔$\angle CI'A > C'HI'$ (##)

Because (#) and (##) are obtained $\angle ACI' < \angle AI'C$, consequently triangle *ACI'* is not an isosceles triangle. (###)

Suppose *I* to *AI'* that is triangle *CAI"*
$\angle AI"C = \angle CI'A + \angle I'CI"$
➔$\angle AI"C > \angle CI'A$ (*)
$\angle ACI" < \angle ACI'$ (**)

Because $\angle ACI' < \angle AI'C$and (*) (**), then
$\angle ACI" < \angle AI"C$,

since *CAI"*is not an isosceles triangle. (***)

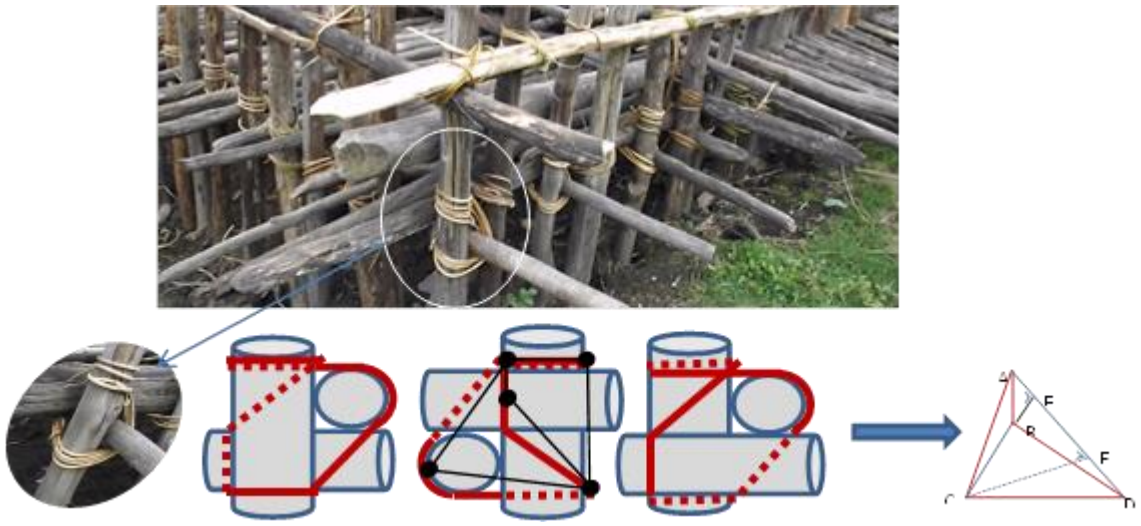

Figure 5. Knot floor frame and geometric models.

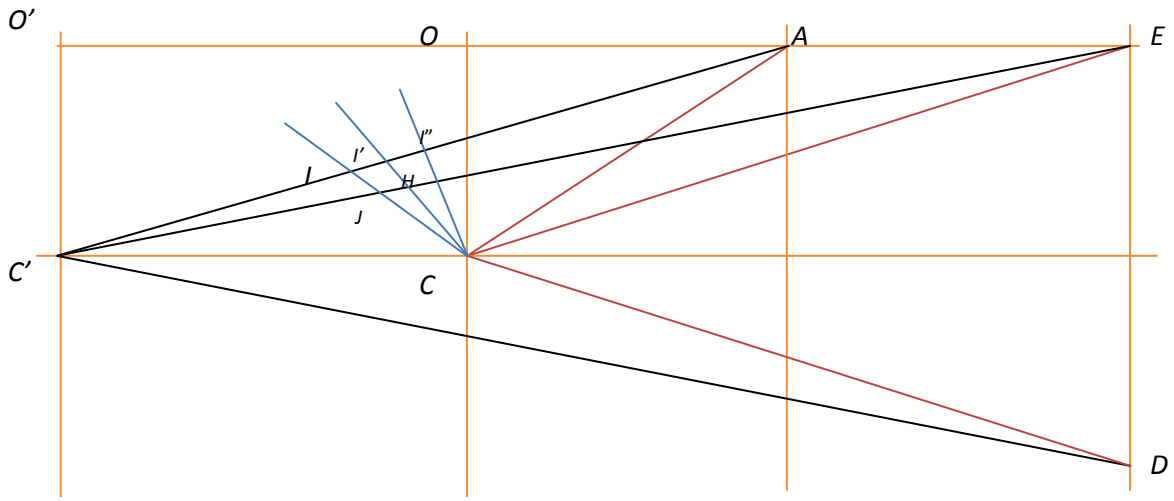

Figure 6. Wall frame model.

Based on (###) and (***), the point *I* is located on the *C'I'*

Furthermore, we will found out the differences between length *C'I and C'H*

Made from point J coordination between *C'I* and *C'H* is obtained:

$\angle C'JI=180^0-\angle JC'C-\angle C'CI$
$\angle C'IC=180^0-\angle IC'C-\angle C'CI$
$\angle JC'C = \angle IC'C- IC'J$

Then
$\angle JC'C < \angle IC'C$

So *IC'* < *C'J*. Cause *C'J* < *C'H*, then *IC'* < *C'H*

Furthermore, we will found out the differences between p and q.

Because
p =HC'–(C'D-CD)
q =IC'–(C'D-CD)

and
IC'< C'H

then
p>q

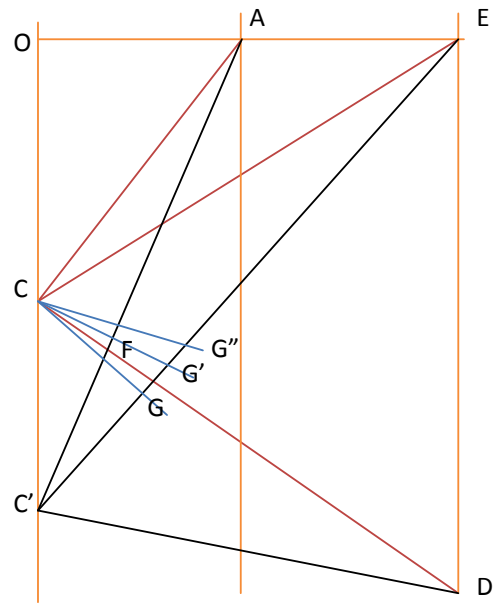

Figure 7. Floor frame model.

Furthermore, if it is determined $p = q$, the obtained $CC' > CC''$ where C 'and C" respectively, is the movement of the rope *ACD* to *AC"D* and *ECD* to *EC'D*.

Analysis of floor frame

If point A and E is the point-the fulcrum of the top pole, points *C* and *C'* is the outer point of the wooden framework of the floor, and D is the fulcrum point on the bottom of the pole. Point O is the point that forms the corner of O = 90^0. From the data the community string is a rope that passes through the point A, C, and D. This knot is used for the framework floor knot, while the framework wall knot is used a knot through point E, C, and D.

Framework floor knot is used to hold the floor not to fall. This knot is designed so that it can withstand heavy loads strongly. Point C 'is the movement points of the point C. The following will be analyzed by comparing with models frame wall knot if it is used as the floor.

The movement from *C* to *C'* viewed from points *A* and *E* as follows:

In point *A* need addition to the length of rope m as follows

$m = (AC'-AC) -(CD-C'D)$

Point *E* requires the addition of a rope as follows (Figure 7)

n = (EC'-EC)-(CD-C'D)

Furthermore, we will look for the difference between m and n.

For the length m

Determined point *D* on the *AC'* with *AD* = *AC*. Consequently will be obtained

$m = C'D -(CD-C'D)$

For the length n

We will find out point *G* so that *EG* = *EC*. If point *G* on the $\overrightarrow{CD}$ is *G'*in Figure 7, by paying attention on triangle *CEG'*,

$\angle ECG' < \angle ACD$
$\angle ACD = \angle ADC$
$\angle ADC = \angle C'DG'$
$\angle CG'E = \angle C'DG' + \angle AC'E$

Then
$\angle CG'E > \angle C'DG'$

Consequently $\angle ECG' < \angle CG'E$. Therefore, the triangle *CEG'* is not isosceles triangle, so

$EG' < EC$.

If G is located between *EG'*for example *G"*. it obviously shows that *EG" <EG'*, consequently

$EG'' < EC.$

As a conclusion the position of point *G* is between *C'G'* is point *G*.

$n = C'G-(CD-C'D)$

Furthermore we will found out the difference between length m and n.

If the intersection of the *CG* and *C'F* is point *H*, because $\angle CGE$ is acute, then $\angle CGC'$ is blunt. As a result, for the triangle *C'GH* is obtained *C'H>C'G*, then *C'F>C'G*. then:

$m > n$

If $m = n$, then $CC' > CC''$ where *C'* and *C"* is the movement of the rope *AC'D* to *ACD* and *ECD* to *EC"D*.

DISCUSSION

From the analysis of the modeling knot strap used in the frame of the floor, the walls were very strong. If the node or floor used for walls or vice versa, then the node is not strong. Arfak tribal society in building a house does mathematical calculations. The concepts used in these nodes is the concept of a triangle, the concept of transformation, the concept of angle, the concept of distance and line concepts.

The concept of the triangle can be seen on each node using a minimum of three points. Two points on one frame and one point to the other frame. If the three points

are connected by lines, the result will form a triangle. This concept can be seen in Figures 3 – 5).

The concept of transformation is used to determine the shifting frame. The community can minimize the shift of the frame. The smaller the shift in frame, then the house is becoming stronger.

The concept of angle, distance concept, and the concept of the line are also available on knot of rumah kaki seribu.

The mathematical model can be used as an ingredient in the learning of mathematics, especially geometry in a formal school in Arfak tribal communities, namely, on the topic of the triangle, transformation, angles and lines.

From that, teachers should not teach Maths in the classroom. For students such as the Arfak tribal ones who are often absent, teachers should give them assignments.

Conclusion

From this study, we can conclude that the method of determining the knot model in frame of the floor and walls knot in rumah kaki seribu by Arfak people has triangular characteristics. They consider the strengthen, endurance, and the stability of their house. Therefore, the thought process of the people, according to Gerdes (1986, 2003, 2014), is geometrically oriented.

In line with learning process in public schools tribe of Papua, a knot in the framework of the wall can be used for learning materials, especially for the topic of triangular geometry, alignment and transformation.

Conflict of Interests

The authors have not declared any conflicts of interest.

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