Ethnomathematics study: uncovering units of length, area, and volume in Kampung Naga Society

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Abstract. During this time, mathematics is considered as something neutral and not associated with culture. It can be seen from mathematics learning in the school which adopt many of foreign mathematics learning are considered more advanced (western). In fact, Indonesia is a rich country in cultural diversity. In the cultural activities, there are mathematical ideas that were considered a important thing in the mathematics learning. A study that examines the idea or mathematical practices in a variety of cultural activities are known as ethnomathematics. In Indonesia, there are some ethnic maintain their ancestral traditions, one of them is Kampung Naga. Therefore, this study was conducted in Kampung Naga. This study aims to uncover units of length, area, and volume used by Kampung Naga society. This study used a qualitative approach and ethnography methods. In this research, data collection is done through the principles of ethnography such as observation, interviews, documentation, and field notes. The results of this study are units of length, area, and volume used by Kampung Naga society and its conversion into standard units. This research is expected to give information to the public that mathematics has a relationship with culture and become recommendation to mathematics curriculum in Indonesia.

1. Introduction

During this time, mathematics is regarded as a perfect science with absolute truth and not related to everyday life.Mathematics always taught at schools as a culturally free subject involved learning that supposedly universally accepted facts, concepts, and contents [1]. Sumardyono [2] states that the objects of mathematics are social-cultural-historical, meaning that mathematics and learning the common property of all the people. Therefore, mathematics has always been part of human culture even in the simplest form. This means that culture and mathematics related each other.

A field of study which is used to show relevancy between culture and mathematics is ethnomatematics. Ethnomathematics defined as a cultural anthropology of mathematics and mathematical education[3,4]. Ethnomathematics consists of two words, "ethno" and "mathematics". The mean of ethno is a cultural group and mathematics considered as a set of activities such as measuring, classifying, sorting, summing, and modelling [5]. Definition of ethnomathematics also expressed by William D Barton. In his dissertation, William D Barton [6] argued that ethnomathematics is a field of study which examines the way people from other cultures understand, articulate and use concepts and practices which are from their culture and which the researcher describes as mathematical.

According to Alan J Bishop [7] mathematical ideas develop anywhere because people living in different cultures may be doing the same thing. Some of the activities done by humans is very important in developing mathematical ideas. Such activity includes counting, locating, measuring, playing games, designing, and explaining. The activity classification is helpful in designing learning to introduce students to mathematical knowledge contained in a culture. With these design students are expected to understand that learning math is fun and useful for real life.

Ethnomatematics research is suitable to do in Indonesia which has a lot of culture. Despite the progress of the times happening, many ethnic in Indonesia who survived by clinging to the doctrine of his ancestors. One of themis Kampung Naga society located in Neglasari Village, Salawu subdisctrict, Tasikmalaya district, West Java Province.

Kampung Naga is a village which adamant to his ancestral traditions, namely Sundanese. Kampung Naga society usesSundanese language as everyday language. They have unique shape of the building, which is shaped house on stilts. Kampung Naga has an area 1.5 hectares. Kampung Naga area may not be increased or reduced. Therefore, no additional buildings or houses in Kampung Naga.

Kampung Naga is beautiful place. To reach Kampung Naga, visitors have to pass through 439 stairs. Rice fields, forests, and rivers can you see when walking down the stairs. Kampung Naga is restricted by a small ditch in the north and south, restricted by a small hill in the west, and restricted by Ciwulanriver in the east. So that, Kampung Naga is surrounded by the natural environment.

The life principle of Kampung Naga society is a live with nature. This is evident from Kampung Naga society efforts to keep preserve nature. They limit the development of technology to get into Kampung Naga. One of them is that there are not an electricity. They did not forbid the technology, but because there is no electricity then it would automatically filter incoming technology. Moreover, the reasons why there are no electricity is because theirhouses are made of materials that flammable and that does not cause social gap between Kampung Naga society.

Based on the results of preliminary studies, one of the cultural activities done by the Kampung Naga society is measurement concept. In measuring activities, Kampung Naga society using auniqueunit of length, area, and volume. Therefore, the aims of this study is to uncover units of length, area, and volume used by Kampung Naga society.Accordingly, the research problems are: (1) How the units of length, area, and volume used by Kampung Naga society? (2) Canthe units are converted into standard units?

2. Experimental Method

The qualitative approach is used in this research because a problems studied related to social life or complex society, holistic and meaningful. Besides that, qualitative approach also allows the researchers to uncover ethnomathematics [6,8]. Ethnographic methods used for this research because researchers will uncover mathematical ideas contained in measuring activity done by Kampung Naga society so that we can uncover the units of length, area, and volume in Kampung Naga society.

In this study, data collection is done by using the ethnography principles that is observation, interviews, documentation, and field notes. Once the data is collected, then analyzed with the measures, namely reducing the data, present data in a short description and a table, and draw conclusions. Test validity of the data is done by using credibility test, transferability test, dependability test, and confirmability test.

3. Result and Discussion

Measuring is an activity that is often done by people in daily activities, including by Kampung Naga society. When measuring length, area, and volume of an object,one used a comparison called unit. Units of length, area, and volume used by a tribe is different depending on the language and measuring instruments used. Because civilization and human culture are growing and expanding with their relationships between communities around the world, then to make easier people to interact with each other made standard units of measurement or what is often referred to International Units.

3.1. Unit of Lenght

In the past times, before using standard measuring tools, Kampung Naga society measured the length of an object by using objects in the surroundings, for example a rope, a stick or a part of the human body. To measure the length and width of the land, Kampung Naga society use a rope. Then the rope was measured by *jeungkal*and marked every one meter by making a knot. The number of knot indicated how many meters length or width of the land.

Units of length which until now used by Kampung Naga society, namely *jeungkal* and *deupa*. There are two opinions in Kampung Naga describing size of *jeungkal*. The first opinion says that one *jeungkal* is a distance from the tip of the thumb to the tip of the middle finger when stretched. Meanwhile, another opinion says that one *jeungkal* is a distance from the tip of the thumb to the tip of the little finger when stretched. Second opinions believe that *sajeungkal*size is about 20 cm.Second opinion of Kampung Naga society the same asElis Suryaniopinion [9]which states that size of *jeungkal*is from the tip of the thumb to the little finger, approximately 20 cm. Figure 1 shows us about how Kampung Naga society use *jeungkal* to measure.

Deupa is a distance from the right hand fingertip and left hand fingertip when stretched. Kampung Naga society believes that if it is converted to meters, then one *deupa* equal to 1.5 meters. According Danadibrata [10]"*deupa nyaéta antara tungtung ramo leungeun katuhu jeung tungtung ramo leungeun kenca lamun leungeun duanana dipanjangkeun, sadeupa kira-kira 1.7 meter*". Based on these opinions, *deupa* is a distance between right hand fingertips and left hand fingertips when arms are both stretched, one *deupa* equals to 1.7 meters. This is different from Kampung Naga society that state*s a deupa* equal to 1.5 meters. These differences may occur because the body size of each person is different.

Beside *jeungkal* and *deupa*, Kampung Naga society also measured object by using the distance between the right hand tip with the left shoulder like Figure 2. The distance between the tip of the right hand with the tip of the left shoulder of approximately 1 meter. Therefore, Kampung Naga society call this measure with *sameter*.

Figure 1. Measurementof *Jeungkal*

Figure 2. Measurementof *Sameter*

Measurement of length with parts of human body have been used by many countries in the world. Each state has units of length almost equal to other regions but with a different name because of differences in the language used. For example, Swahili society, East Africa used the term*shibiri* to the span (*jeungkal*), that is the distance from the tip of the thumb to the tip of your little finger (about 9 inches), *mkono* = 2 *shibiri* to pinch (about a yard), and *pima* = 4*mkono* to fathom (about 2 yards) [11]. Mexico society using the units of length as *cemacolli* (arm), *cemmolicplitl* (bone), *cenmaitl* (hand) or *cenxocpalli* (footprints)[12].

3.2. Unit of Area

Nowadays, land measurementin Kampung Naga society is done by using a meter. Length and width are calculated in meters, but then the result is converted into a unit, namely *bata* or *tumbak*. *Bata* was being used from ancient times to the present. Kampung Naga society believe that 1 *bata* equals to 14

m^2. If the land is rectangular, then one *bata* of that land area is the area of land which is have length 3.75 m.

Besides*bata*, unit of area known by Kampung Naga society are *areu* and *bau*. If *areu* is converted to square meter, then 1 *areu* = 100 m^2. Meanwhile, if converted into *bata*, then 1 *areu* = 7 *bata*. So, 1 *areu* = 100 m^2 = 7 *bata*. Thus obtained 1 m^2 = 0.07 *bata*. Size 100 m^2 = 7 *bata* is used by the government to convert square meters into *bata*. For *bau* unit,Kampung Naga society states that one *bau* equal to 100 *bata*. Thus, *sabau* = 100 *bata* = 1.400 m^2. Whereas, if use the government system, 1 *bau* = 100 *bata* = 1.428, 57 m^2.

Danadibrata[10] states that *"bata nyaéta ukuran legana sawah atawa tanah, sok disebut ogé tumbak. Sabata = satumbak= 14.193 m^2"*. Based on these opinions *bata*is a size of farm or land area, also called *tumbak*. In this case, the size of the batain Kampung Naga society equal to Danadibrata's opinion. This means, the size of the batain Kampung Naga society is equal to the size of *bata* in Sundanese people in general, just the size 1 *bata*in Kampung Naga society is rounded to 14 m^2.

According Danadibrata[10], *"bau nyaéta ukuran legana sawah atanapi tanah. Sabau = 500 tumbak/bata = 7,096.5 m^2"*. Based on these opinions *bau*is a size of land area. It can be concluded that *bau* used by Kampung Naga society and Sundanese people in general wasdifferent. If normally in Sundasociety 1 *bau* was equal to 500 *bata* (*tumbak*), in Kampung Naga society 1 *bau* equal to 100 *bata*.

According Claudia Zaslavsky[11], the Ethiopian ancient used the unit *acre* for area of land. *Acres* represents the number of land plowed by a pair of bulls in one day. In Indonesia in the 9th century widely known unit of measure, such as *barih, latir, tu, tampah, tampah haji, suku, hamat, blah, jong, lirih, kunci,* and*pecal*. These terms werefound on inscription in the early 9th century, found in the Temanggung. During this period, the size of the land area is usually calculated based on the number of seeds that can be planted on the land. Therefore, the size of the unit area is always preceded by the number of seeds[13].

3.3. Unit of Volume

The use of unit volume saw in the measurement of wood. Wood was one of the materials used in the construction of houses in Kampung Naga society. The wood was taken from the garden, located about 500 m from Kampung Naga. Construction of houses in Kampung Naga is almost nothing else because of the limited area. However, the calculation of the wood is still used in a house renovation. In the construction of the house, wood used as a pillar, rafters, *palang dada*, and the board. A form of pillar, rafters, *palang dada*, and the boardcan be observed as at fFigure 3 and Figure 4. The calculation volume of wood is done by multiplying the length, width, and thickness of the wood. Mathematically, the calculation volume of wood is written: "Volume = length × width × thickness". Then, the units expressed in *elo, dim, strip*, and *kibik*.

Figure 3. Pillar, *Palang Dada*, and Board

Figure 4. Rafters

3.3.1. Pillar

Pillar used by Kampung Naga society has widths and thicknesses of 10 cm wood. Whereas, for its length adjusted to the needs. Calculation of pillar volume in KampungNaga was done without converting the units into same unit. But at the end of calculation, a result divide by a hundred. Then, the results are expressed in units called *élo*. From the calculation of pillar volume in Kampung Naga, this can be developed a mathematical model: Vt = (p)*élo,*with Vt ispillar volume and p is pillar length (in meters).

In this section, researchers also tried to calculate a pillar volume which has two meters of length. The first, researcher convert meter unit into centimeter. Here is the process of counting

Pillar Volume = 2 m × 10 cm ×10 cm = 200 cm × 10 cm × 10 cm= 20,000 cm^3

Based on the mathematical model above, volume of the pillar which has length 2 meters is 2 *élo*. Thus, the pillar volume = 2 *élo* = 20,000 cm^3. Then, we conclude that 1 *élo* = 10.000 cm^3 = 0,01m^3

Kampung Naga society call 1 m^3 with *sakibik,* so that 1 *kibik*= 1 m^3 = 100*élo*. Kampung Naga society has learned that 1 *kibik* = 100 *élo*. This shows that since old time Kampung Naga society has the ability to convert the unit well. But, a term of unitsbeing used in Kampung Naga have different with the unit that has been standardized.

3.3.2. Rafters

Kampung Naga society has been using rafters which has a size of 6 cm for a thick and 6 cm for a wide. For a size of a length adjusted to a needs. Calculation of volume rafters is slightly different to the pillar volume. If at the end of pillar volume calculations are performed division with a hundred number and the results are expressed in élo units, at the calculation of rafting volume divide with ten number and expressed in a dim units. Calculation of rafters volume in Kampung Naga society can be developed a mathematical model: Vk = (3,6× p) dim, with Vk is rafters volume and p is rafters length (in meters).

Researchers attempt to calculate rafters volume with previously convert meters unit to centimeters.

Volume kaso-kaso = 2 m × 6 cm × 6 cm = 200 cm × 6 cm × 6 cm = 7.200 cm^3= 0,0072 m^3

From a calculation of Kampung Naga people, rafters volume is 7 dim 2 strip. So:

7 *dim* 2 *strip* = 7.2 *dim*

2 *strip* = 0.2 *dim*

1 *strip* = 0.1 *dim* atau 1 *dim* = 10 *strip*

7 *dim* 2 *strip* = 7.2 *dim* = 0.0072 m^3

1 *dim* = 0.001 m^3 = 1 dm^3

1.000 *dim* = 1 m^3 = 1,000 dm^3

From the previous calculations, be obtained that 1 *kibik* = 1 m^3 = 100 *élo.* Because 1 m^3 = 1,000 dim, then 1 *kibik* = 1 m^3 = 100 *élo* = 1,000 *dim* = 1,000 dm^3.

Based on the calculations above, it can be concluded that 1 *kibik* = 100 élo = 1,000 dim, 1 *élo* = 10 dim, and 1 *dim* = 1 dm^3 = 1 liter.

Thus, the mathematical model for rafters volume can be written as follows.

Vk = (3.6 × p) dim = (3.6 × p) dm^3orVk = (3.6 × p) *élo*, with Vk is rafters volume and p is rafters length (in meters).

3.3.3. Palang Dada

Size of *palang dada*have been using by Kampung Naga society is 10 cm for wide and 5 cm for thick, with a length adapted to the needs. The process of calculating *palang dada*volumeis equal to pillar volume. Here is a form of mathematical models of the *palang dada*volume :Vpd = (0.5 × p) *élo.*With Vpd is*palang dada* volume and p is*palang dada* length (in meters).

3.3.4. Board

Wooden boardwas used for flooring of buildings in Kampung Naga. The floor boards are used in almost every room of the house, except in the kitchen that uses Palupuh floor made from bamboo. The

size of the floor board used by Kampung Naga society is 20 cm of wide and 3 cm of thick, with a length adapted to the needs. Calculation of volume board is the same as the calculation of pillar volume and *palang dada*. Here is a form of mathematical models of the board volume: Vp = (0.6 × p) *élo.*With Vp is board volume and p is board length (in meters).

In olden times, humans measure the volume and weight by using the objects so that the unit was usually still associated with the objects used. For example, if the measure of sugar with a spoon, then the units used are spoons. According Claudia Zaslavsky[10], Swahili, East Africa know *kibaba* unit, *kisaga*, and *pishi* to unit of volume. One *kibaba* is one cask (pint), one *kisaga* = 2 *kibaba* or about a quarter gallon, and one *pishi* = 2 *kisaga* or half-gallon size. Meanwhile, In Mexico known units of volume are *acalli, cemixcolli, cemacuahuitl, cenxumatli, centcuauhxumatli, cempopolli, centlachipinilli,* and*centlamapictli*[12].

From explanation above, it was clear that each region has unique units in the measurement of length, area, and volume. It shows the cultural richness of each region in the world. Therefore, researchers hope that mathematical knowledge incorporated into the school curriculum not only mathematical knowledge that comes from the West, but also mathematical knowledge comes from every region in the world.

4. Conclusion

Ethnomathematics study in the domain of education can be used to uncover the ideas in a cultural activities or social groups to develop mathematics curriculum for, with, and by the group. Thus, mathematics can have different shapes and develop suitable with each culture. The result of this study is a form of units of length, area, and volume in Kampung Naga society. Until now, Kampung Naga society uses typical units obtained hereditary. Unit of length used by Kampung Naga society, namely *jeungkal*, *deupa*, and *sameter*. Unit of area used by Kampung Naga society, namely *bata*, *areu*, and *bau*. Unit of volume used by Kampung Naga society, namely *élo, dim, strip,* and *kibik*. This study revealed the conversion of units of length, area, and volume in Kampung Naga society into standard units. In addition, in the context of the wood volume measurements revealed models of mathematics that can facilitate cultural actors in calculating the volume of wood (pillar, rafters, *palang dada*, and board). The results of this study can be used as a reference to develop learning materials of contextual mathematicsbased on local culture, which is expected to reduce the public perception that mathematics does not have relevance to daily life.

5. References

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