Ethnomathematics exploration on units and calculus within a village farmer community

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Abstract. Ethnomathematics is the study of specific patterns or certain colours of mathematics that live and develop in society. Ethnomathematics is mathematics that arises or is used by cultural groups, such as urban and rural communities, labor groups, children of a certain age, indigenous peoples, and others. Agriculture is a culture as well as the livelihood of most Indonesian people, especially the Suranenggala Kidul Village Community of Cirebon. In farming activities, there are mathematical terms used, ranging from units of measurement, concepts of sequence and series, concepts of algebra, geometry, and calculus concepts. This study aims to show the relationship between culture and mathematics that can be used as a learning approach in school and included in the type of qualitative ethnographic method research. Research data is obtained by the process of observation, interviews, and documentation. Based on the results of preliminary observations indicate that the community activities of the Suranenggala Kidul Village village of Cirebon contain mathematical elements in the form of a specific unit such as length unit, area unit, and volume unit, as well as high-level mathematics that can be used as a media or approach in learning mathematics in schools. Therefore, it is necessary to investigate further the ethnomathematics of peasant communities in Cirebon regency primarily in the Suranenggala Kidul area.

1. Introduction
Mathematics is a science that develops with society, but some people do not realise that they have used mathematics in their lives. This view indicates the assumption that mathematics is not related to real life, even though mathematics is in daily activities, for example in games, buying and selling transactions, calculating, measuring, comparing, sorting, and designing buildings. These activities are the knowledge that applies mathematical concepts ranging from simple to complex ones. Mathematics appears in everyday life [1]. Mathematics is a science that is related to any activity in real life [2]. Some expert opinions show that mathematics has played a role in life and has become a human activity in everyday life.

In line with mathematics, culture develops and lives in community habits inherited from generation to generation. Community culture with one another is indeed not the same. Therefore, culture is a characteristic and identity that is the work of humans. Culture has gradually undergone a development process by the times and human knowledge to adapt to its environment. A sociologist defines culture with all skills (customs, morals, art, science etc.). While historians interpret culture as inheritance or tradition. Even Anthropologists see culture as a system of life, way of life, and behaviour [3]. With this, it can be said that culture is a form of common sense and mind. However, along with the development of modern technology, the regional culture that was originally held firmly, maintained and maintained its existence has now begun to be forgotten. Whereas culture is a nation's wealth that is priceless and is a heritage that deserves to be preserved. One way to preserve culture so as not to be forgotten is to instil cultural values early on to individuals of the next generation. Because culture is the result of human
work, the process of cultivating cultural values can be done through the family, community, and education environment.

Ethnomathematics is a term that arises based on the similarities between culture and mathematics which are studies to find special or unique patterns in mathematics that emerge and develop in certain groups of people. Ethnomathematics grows and develops from culture so that the existence of ethnomathematics is often not realized by the user community. Ethnomathematics itself uses a broad mathematical concept related to mathematical activities. That is, ethnomathematics is not fixed on a theoretical study, including agriculture, architecture, clothing motifs, weaving, ornaments, kinship and spiritual relations [3]. A lot of ethnomathematics studies have been carried out in Indonesia, such as an explanation of the Balinese calendar which contains mathematical elements in the form of numbers and least common multiple [4], other research conducted on Jember coastal communities that contain the sequence and series characteristics, geometry, social arithmetic and modulo [5], even studies related to agricultural communities have already been precisely in the Java region of Setail Banyuwangi Village [6]. The research that discussed the cultural and mathematical linkages that had been carried out in the Java region had been carried out, such as in Cirebon as well as the study of the Trusmi Cirebon batik motifs related to aboge (alif, rebo, wage) which was carried out by the Kasepuhan Palace in Cirebon which contained elements of modulo which were part of mathematics [7], as well as research on the Archaeological Well in Kaliwadas Village, Cirebon, discusses the form of wells through a mathematical approach, namely the limit of the sequence [8]. In addition to those mentioned, one of the interesting Cirebon cultures to study is about the culture of the community in Suranenggala Kidul Village Farmers, which contains many mathematical materials such as number patterns, arithmetic and geometric patterns, measurements, the volume of rotating objects and so on.

Agriculture is the culture and livelihood of most Indonesian people. Agriculture is an Indonesian community cultural activity [9]. Geographically, Cirebon is the province of West Java, which is located in the east and is the boundary, as well as the gateway to Central Java Province. In the agricultural sector, Cirebon is an area for producing rice. Talking that rice cannot be separated from fields, fields are places that have a certain shape and are places where rice is planted. That a field is a form of wetland agriculture which is limited by small embankment used to hold/distribute water [10]. In agricultural activities both in the process of planting and harvesting, various mathematical concepts have been discovered that unconsciously the community has used it in everyday life, such as counting, measuring, calculating, unit area, unit length, and unit volume. Ethnomathematics activities in agriculture can be integrated into the learning process. The research aims to explore ethnomathematics as a teaching material using an agricultural approach to understand the concepts of sequence and series, geometry, and calculus.

2. Method

This research is included in the type of qualitative research. This study aims to identify the mathematical aspects that exist in the culture of the Suranenggala Kidul Village Farmers in Cirebon. Qualitative research aims to understand the phenomenon of what is experienced by the subject of research such as behaviour, perception, motivation, action, holistically, and using a description in the form of words and language, in a special context that is natural and by utilizing various scientific methods [11]. The research method used is an ethnographic method. Ethnography is an effort made to explain culture or aspects. This research method aims to get an in-depth description and analysis of culture based on intensive field research. The research area used in this study was Suranenggala Kidul Village Cirebon. Research data is obtained by the process of observation, interviews, and documentation. The data analysis is done by grouping the research data at the time of observation, interview and organizing data sources by the focus of problem and research objectives, namely identifying mathematical aspects in geometry, algebra and arithmetic. This phase to show the process of thinking mathematically in the village farmers community of Suranenggala Kidul. The next phase is triangulation. Triangulation is used to verify data taken from sources in the form of data collection directly from research subjects, both from observations and interviews. This stage is the main objective of the research, which is to describe the activities of the farming community in Suranenggala Kidul Village, Cirebon. Through phases in the method, it can be shown that the activities of the Suranenggala Kidul Village Cirebon community contained mathematical elements in the form of certain units such as units of length, unit area, unit of volume, arithmetic & geometry, and calculus.
3. Result and Discussion

Based on the results of the study, it can be seen that the farming activities of the Suranenggala Kidul Village in Cirebon contained mathematical activities that emerged. These math activities include measuring. Measuring activity arises when the farming community calculates the area of fields. Wide units are used in various kinds, ranging from sejari/prawolu, seprapat, selumpit, sebau, and sektar. There is a relationship between using a number pattern system. Number pattern is an order that is formed in such a way, both in the form of real and imagination [12]. Other sources state that number patterns are numbers sorted by a particular rule so that the numbers in the set form a pattern [13].

Table 1. Size of field

| Unit terms       | Conversion |
|------------------|------------|
| Sejari/prawolu   | $\frac{1}{4} \times$ lumpit |
| Seprapat         | $\frac{1}{2} \times$ lumpit |
| Selumpit         | $1 \times$ lumpit |
| Sebau            | $2 \times$ lumpit |
| Sektar           | $3 \times$ lumpit |

From the results above shows that farmers use the terms sejari/prawolu, seprapat, selumpit, sebau, and sektar to measure the area of fields. These terms are said to have existed since time immemorial, for example only the smell that comes from Dutch from the word bouw which means arable. Bau and lumpit are ancient terms that are often used by Javanese as a unit in measuring fields up to now. While seprapat is the word of a quarter, which is a numeralia of fractional forms. As for sejari / prawolon is another word from one-eighth which is also a numeralia of fractions. And then sektar is another word for acres which is an international unit.

Table 2. Size of field in bau

| Size of field (Javanese) | Size of field (Indonesian) | Wide size of fields (Mathematical Form) | The amount in (brick) |
|--------------------------|----------------------------|----------------------------------------|----------------------|
| Sektar                   | Satu hektar                | $\frac{3}{2} \times$ bau              | 750 bata             |
| Sebau                    | Satu bau                   | $1 \times$ bau                         | 500 bata             |
| Selumpit                 | Satu lumpit                | $\frac{1}{2} \times$ bau              | 250 bata             |
| Seperapat                | Seperempat                 | $\frac{1}{4} \times$ bau              | 125 bata             |
| Sejari/prawolu           | $\text{Satu}\ \text{jari/seperdelapan}$ | $\frac{1}{8} \times$ bau | 62,5 bata |

Information: 1 bau = 500 bata

Table 3. Size of the field in lumpit

| Size of field (Javanese) | Size of field (Indonesian) | Wide size of fields (Mathematical Form) | The amount in (brick) |
|--------------------------|----------------------------|----------------------------------------|----------------------|
| Sejari/prawolu           | $\text{Satu}\ \text{jari/seperdelapan}$ | $\frac{1}{4} \times$ lumpit | 62,5 bata |
| Seprapat                 | Seperempat                 | $\frac{1}{2} \times$ lumpit           | 125 bata             |
| Selumpit                 | Satu lumpit                | $1 \times$ lumpit                      | 250 bata             |
| Sebau                    | Satu bau                   | $2 \times$ lumpit                      | 500 bata             |
| Sektar                   | Satu hektar                | $3 \times$ lumpit                      | 750 bata             |

Information: 1 lumpit = 250 bata
In addition to the terms of the paddy field unit, there is ethnomathematics in the process of measuring broadly, namely in the activities of measuring the field. In measuring the area of paddy fields, local people use the concept of a plane that is learned at school. Suppose it is square then they will use the square formula to calculate the area. Calculating the area of fields usually uses formulas learned at school [14]. However, if the paddy fields are breech or each side is different in length, then the community uses a simple method. The method of calculating the area is: to get the length they add up the first and second sides then divide by two, and to calculate the width they add up the third and fourth sides then divided by two.

Figure 1. Fields and sketches

To look for length \((L)\), that is \(L = (I + II)/2\)
To find width \((W)\), that is \(W = (III + IV)/2\)
So area \((A)\), \(A = L \times W\)

After obtaining the length and width, the area can be searched by using a rectangular concept, how to measure this kind of rice has been agreed by the local community to be used as a reference in measuring the area of fields.

If examined more in this kind of calculation is a mathematical concept using the concept of any trapezoid. Any trapezoid is a quadrilateral with a pair of opposite sides parallel and having a different side length [15]. Say that any trapezoid is a rectangular flat with parallel sides and not equal lengths [16]. So the result of the calculation according to the subject is the concept of any trapezoid.

In addition measuring activities can also be found when the community performs rice measuring activities, where the community uses certain terms that are classified as unique because coconut shells are used as a reference, such as a bucket of wool which when converted into two coconut shells, then a seter which has four coconut shells, and sekocel are terms that are equivalent to six coconut shells, the last being while the number of shells is eight coconut shells.

Some terms regarding the unit of measurement of area and the unit of volume used by the community are the basic concepts of mathematics, especially the material of social arithmetic, arithmetic, geometry and calculus series and calculus.

| Shell size (Javanese) | Size of the shell (Indonesian) | Shell Size (Mathematics) |
|-----------------------|-------------------------------|-------------------------|
| Sebatok wolu          | 1 batok wolu                  | 2 batok kelapa          |
| Seter                 | 1 eter                        | 4 batok kelapa          |
| Sekocel               | 1 kocel                       | 8 batok kelapa          |
| Sedangan              | 1 dangan                      | 16 batok kelapa         |
The number of coconut shells in the existing unit shows the existence of a pattern, if we associate it with the geometric sequence material is obtained 2, 4, 8, 16, because the comparison (ratio) of two consecutive terms is the same, that is 2. Then the sequence of numbers is a row geometry. That geometric sequence is a line \( U_1, U_2, U_3, \ldots, U_n, U_{n+1} \). If for each \( n \) real number applies \( \frac{U_{n+1}}{U_n} = \frac{U_n}{U_{n-1}} = \cdots = \frac{U_2}{U_1} = r \) (17). So 2, 4, 8, 16 is a geometric sequence with formulas \( U_n = 2^n \), with \( n = 1, 2, 3 \).

A shell is a tool used in measuring rice has a large and small size, but generally, people use a small size. The size of a small shell has a diameter of about 13 cm. The shape of coconut shells and the way people measure rice turns out to have something to do with other mathematical concepts, namely the main calculus is the concept of the volume of a rotating object, the rotating object is a flat area that is fixed in a plane and divided by the rotary axis, then rotated around the axis (18). The following analysis is carried out in looking at the link between the volume of the shell and the mass of rice.

**Figure 2. Batok (coconut shell)**

Figure 2 is a picture of a coconut shell which is commonly known as coconut shell, coconut shell itself is used by the people of Suranenggala Kidul Village as a rice marker, regarding the size of the coconut shell there are two types, large and small. The shell in the picture above includes a small coconut shell.

**Figure 3. Shell Sketch**

Figure 3 is a sketch of a coconut shell that has a diameter of 13 cm. The sketch was obtained with the help of a GeoGebra program, resulting in an equation \( f(x) = \sqrt{(6.5)^2 - x^2} \), then from the equation can be obtained a volume of a rotating object.

\[
V = \pi \int_{a}^{b} (f(x))^2 \, dx
\]
The volume calculation results show that one shell has a mass of 0.43 kg. This means that the subject statement regarding the amount of sedangan equivalent to 6 kg is relatively the same. Because sedangan is equal to 16 shells, 0.43 kg × 16 shells = 6.8 kg. This shows that shells are a measuring tool that can be used to measure agricultural products.

4. Conclusions
Based on the results of the analysis, it can be concluded that there are ethnomathematics activities in farming activities carried out by the people of Suranenggala Kidul Village, Cirebon. Ethnomathematics activities include measuring the area of fields and measuring rice activities. In these activities, mathematical concepts emerged such as the concept of ranks and series, concepts of geometry, and concepts of calculus.

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References
[1] D’Ambrosio 2001 Ethnomathematics: Link between traditions and modernity (Rotterdam/Taipei: Sense Publishers)
[2] Muhtadi D, Sukirwan, Warsito, & Prahmana R C I 2017 Sundanese Ethnomathematics: Mathematical Activities in Estimating, Measuring, and Making Patterns Journal on Mathematics Education 8 185
[3] Wahyuni, Tias A A W and Sani B 2013 Peran Etnomatematika dalam Membangun Karakter Bangsa Prosiding Seminar Nasional Matematika dan Pendidikan Matematika FMIPA UNY pp 113
[4] Suarjana I M, Suharta I G P and Japa I G N 2014 Etnomatematika kalender Bali Seminar Nasional Riset Inovatif II 177
[5] Darmayasa J B, Wahyudin, Mulyana T & Noto M S 2018 Remembering the hindu festivities mathematically by the balinese using integer operations and least common multiple Journal of Physics: Conference Series 1008
[6] Wahyuni 2016 Eksplorasi etnomatematika masyarakat pesisir selatan kecamatan puger
Kabupaten Jember: FENOMENA 15 225

[7] Fadlilah U, Trapsilasiswi D, & Oktavianingtyas E 2015 identifikasi aktivitas etnomatematika petani padi pada masyarakat jawa di desa setail Kadikma 6 45

[8] Syahrin M A, Turmudi, & Puspita E 2015 Study ethnomathematics of aboge (alif, rebo, wage) calendar as determinant of the great days of Islam and traditional ceremony in Cirebon Kasepuhan Palace Proceedings of International Seminar on Mathematics, Science, and Computer Science Education pp 1-10

[9] Fatchurrahman 2017 Etnomatematika Sumur Purbakala Desa Kaliwadas Cirebon

[10] Supriatna and Nurcahyono 2017 Etnomatematika: Pembelajaran Matematika Berdasarkan Tahapan-tahapan Kegiatan Bercocok Tanam Seminar Nasional Pendidikan 2017 pp 26-32

[11] Ikrimah I, Rahmi M, and Darmawan R N 2017 Studi Etnomatematika di Kalangan Petani Desa Kelir Kecamatan Kalipuro Transformasi: Jurnal Pendidikan Matematika dan Matematika 1 50

[12] Moleong 2007 Metode Penelitian Kualitatif (Bandung: PT Remaja Rosdakarya)

[13] Shadiq 2007 Apa dan mengapa matematika begitu penting Edumat: Jurnal Edukasi Matematika 7 792

[14] Djumanta and Susanti 2008 Belajar Matematika Aktif dan Menyenangkan (Jakarta: PT Setia Purna Inves)

[15] Aini 2018 Etnomatematika: matematika dalam kehidupan petani di Kabupaten Karawang Jurnal teori dan riset matematika (TEOREMA) 2 101

[16] Wulandari 2016 Installing the concept of geometry form Jurnal pengabdian masyarakat IPTEKS 3 1

[17] Djahir 2017 Matematika bangun datar (Jakarta: kemendikbud)

[18] Adinawan 2010 Instan Matematika (Jakarta: Erlangga)