Ethnomathematical Ideas in The Weaving Practice of Adonara Society

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Abstract

This paper describes the mathematical ideas of Adonara people when engaged in the weaving practice. Data collection was conducted using participatory observation, unstructured interviews, and collection of artifacts including video recordings and photos.
Bishop six mathematical activities including Counting, Location, Measuring, Playing, Designing, and Explaining-CMLDPE was employed as a framework to analyze the data. Results of the study describe the mathematical ideas that emerged in the weaving activity such as counting, determining the location of the object, measuring, designing, explaining, comparing, classifying, using implication logic, palindromic numbers, and various geometry concepts.

Keywords: Counting, Ethnomathematics, *Kewatek*, Measuring, Palindromic,

Introduction

Woven Cloth

Indonesia is a multicultural and diverse country. One of the numerous cultural diversities is manifested in the number of ways the locals dress and in the type of fabric used to make clothes. For example, in the Java community the batik fabric is popular, whereas in East Nusa Tenggara (NTT) community woven fabric is commonly used.

NTT is an island province that mirrors the demographics in Indonesia, with more than 40 ethnicities, each speaking more than one hundred languages and dialects (Sanga, 2004; Liliweri, 2014). The multiplicity of languages and dialects has an impact on the diversity of motifs or patterns designed on woven cloths.

Motifs in woven cloth are not the same in every ethnicity. The motif designed on woven fabric is a manifestation of everyday life and has emotional bonding with people in every ethnicity. Motifs in woven cloths can display the myths, legends, and animals. Motifs also depict the natural local wealth and the relationship between humans and nature. For example a horse motif on Sumba fabric indicates that Sumba has a peculiar kind of horse known as sandalwood horse. A *komodo* motif on Manggarai fabric represents a giant prehistoric lizard found on Komodo island, which is a domestic and international tourism destination.

Various motifs of woven cloths are also representative of the many kingdoms of NTT scattered on the islands of Timor, Flores, Rote, Sumba, and Alor. The first empire in NTT was founded around the 3rd century AD. One of the high cultural art of people is the ability to weave (Liliweri, 2014). Thus, the practice transferred from one generation to the next generation. The weaving practice is not only a leisure activity, but it has become a livelihood. Women generally carry out of the weaving, so this ability can often be a requirement for a woman to get married.

Traditionally, in the process of weaving there are two stages: the first stage involves producing yarn from cotton or leather fiber and the second stage involves producing fabric or cloth. In all these stages, various tools, equipment and materials are used. The weaving equipment are handmade by the weavers themselves to conduct the weaving practice.

Adonara woven cloth can be ***nowi*** (cloth for men), ***kewatek*** (cloth for women), and ***senae*** (shawl). ***Nowi*** is only one type with a size of usually 5-7 spans in width and 6-7 spans in length. There are several types of *kewatek* with size of 4-5 spans in width and 6-7 spans in length. *Kewatek* is used as replies by female family to male family in marriage tradition (Dominikus et al, 2016). ***Senae*** (shawl) size of 1- 3 spans in width and 5-7 spans in length with a variety of motifs for various designated purpose.

Kewatek and ***senae*** cloths have various motifs that also distinguish the selling price. Motifs or patterns that are common in *kewatek penetoten* cloth includes: *kolon matan* (bird's eye), *ule* (caterpillar), *Lako Dowa* (creeping weasel), *kau nepin* (lying palm leaves), *ile wurune* (mountain), and *makoken* (bowl). There is also another motif developed by the weavers today namely *muko kena'lan* (slices of bananas), *karo lolon* (leaf), *kuku beak* (butterfly), a trophy, and combined motifs.

Generally, a piece of *kewatek* cloth is sold between Rp. 130,000 and Rp. 150,000 ($13 USD - $15 USD). Special for *kewatek penetoten* cloth is sold at a price of Rp. 150,000 to Rp. 180,000 ($15 USD - $18 USD), *kewatek lephan* and *kewatek mowak* are sold at a price of Rp. 180,000 to Rp. 200,000 ($18 USD - $20 USD), and *nowi* is sold at Rp. 150.000 ($15 USD). This price could go up depending on the price of yarn.

Ethnomathematics

The definition of ethnomathematics evolved since it was first introduced by D'Ambrosio in the early 1980s. At first ethnomathematics related to the mathematical practice of illiterate people and primitive societies, which do not use written texts (Ascher, 1997; D'Ambrosio, 1997). Here Ascher and D'Ambrosio emphasized that the focus of ethnomathematics was limited to communities that never learned mathematics at school.

On the other hand, ethnomathematics has been defined as a form of mathematics that is contained in the cultural activities of various cultural groups such as ethnic communities, labor groups, children of certain age groups, professional groups, and others (Nunes, 1992; D'Ambrosio, 1997). Milroy (1992) argued that ethnomathematics deals with the study of different types of mathematics that arise or exist in a variety of cultural groups. In a similar vein, ethnomathematics has been associated with a form of cultural knowledge inherent in the social activities of a community or culture (Presmeg, 2007). Mathematical knowledge of a cultural group can be recognized in the jargon, symbols, myths, and in certain ways used by the people for calculating, concluding, sorting, and grouping (François, 2012; Meaney et al, 2008). Some definitions above describe ethnomathematics in relation to the mathematical practices of a particular cultural group.

More recently, ethnomathematics has become a research field studying mathematics in culture (Gerdes, 2014), the relationships between culture and mathematics (Barton, 1996; Alangui, 2006), and the role and influence of ethnomathematics in mathematics and mathematics education (Begg, 2006; D 'Ambrosio, 2001a; 2001b; Horsthemke, 2007). In these contexts, we argue that ethnomathematics can enrich the mathematics commonly known and studied in formal educational institutions ultimately affecting the field of mathematics education.

This study describes the mathematical ideas of Adonara society that are inherent in the weaving process from getting yarn and generating woven cloth, to selling the woven cloth. We contend that results of this research can inform the development of culturally based mathematics learning.

Research method

This research is a qualitative-descriptive study with the aim to describe the mathematical ideas inherent in the weaving practice of Adonara society. Data were collected using participatory observations, unstructured interviews, and collection of artifacts. The participants of the study include 12 female weavers of varying ages: three woman were 61-75 years old, seven woman were 50-60 years old, one was 24 years old, and another 19 years old. In terms of education levels, three of the women never attended school, six women completed primary school, two completed junior high school, and another complete her high school degree. Data were analyzed descriptively using Bishop's (1988) mathematical activities model consisting of: counting, locating, measuring, designing, playing, and explaining.

Informants were key person in the village where the study took place and were selected based on preliminary observations conducted a year prior to the study.Two interviews were administrated. The aim of the second interview was to confirm the data and validate the findings. Interviews included open-ended question and were conducted in the local language as per the prepared interview protocol and in the participants' natural setting. Informants were asked to explain the weaving process and equipment and employed. Observation focused on the weaving process scene, equipment used , the type of fabrics woven, and the design of motifs on fabrics. Documentation and artifacts collection were conducted using video recording and photo taking.

Data analysis was performed on the process of producing yarn, the process of producing woven fabric, and motifs on woven cloths. Results of the analysis describes several mathematical activities and concepts that emerged during the weaving process such as classifying, comparing, the use of logic, palindromic numbers, and various geometry concepts.

Findings and Discussion

Based on the interviews, field observations, and relevant collection of artifacts from the field, we ascertain a number of mathematical ideas practiced by the weavers. The mathematical ideas were evident in the entire weaving process starting from selecting the appropriate yarn, to weaving the motif, and selling the woven cloth. The mathematical ideas that prevailed include:

1. Counting and Adding

The weaver counts the number of yarns to produce woven cloth as follow.

kewatek to'u ne benang ko'ten aen pulurua. Mea'n ni pulokrua, mitene ni buto, nage senegaten ni teke rua ke mupune naen pulurua raine. (A piece of cloth needs more than 20 bonds of yarn. The red yarn is more than 10 bonds, the black one is 8 bonds, and the others are two bonds, so it is entirely more than 20.

The statement of the weavers above could be represented in the following mathematical model as:

12 (red yarn) + 8 (black yarn) + 2 more (other colors of yarn) = more than 20 bonds of yarn.

Also

... kewatek nae ne benang mea'n ne ko'ten 6, mitene koten 4, senegaten di wa' ke mupune naen pulo raine. (... For one part of cloth, 6 bundles of red yarn, 4 bundles of black yarn, and the other is more than 1 so that the whole is more than 10 bundles).

The corresponding mathematical model can be represented as follows:

6 (red yarn) + 4 (black yarn) + 1 more (other colors of yarn) = more than 10 bonds of yarn.

Both models illustrate the fact that the addition operation is performed by summing the numbers that appear regardless of the attributes associated with that number. It shows that concepts of set and subset are inherent within the weaving activity. The counting process so-calleds ***pupu*** (collect) and the result of the action referred to ***mupune*** (overall).

In contrast to the addition process is the activity of rolling the yarn to be *udu* using the bobbin named *temue* (Figure 1c).

... turun benang klo'lon kune' tua ke mian kame tali ko'ten tou mu ti taan ko'ten rua nage kame pudun (...because it is too small pieces of string, we'll add 1 more spinning so become 2 then we roll them in one roll of yarn)

The corresponding additive mathematical model is:

1 (spun yarn) + 1 (spun yarn) = 2 (spun yarn)

The addition operation performed by the weavers was in accordance with the addition procedure taught in school. For example, in the yarn rolling process, two bundles of yarn with the same color were considered. The counting process so-calleds ***tali*** (add more) and the result of the actions referred to ***mupune*** (overall). We argue that Adonara people use two additive models in their weaving practice of ***pupu*** and ***tali.***

1a: Menalok 1b*: Belawa* *1c: Temue*

Figure 1. Weaving Equipments (Photo by Researcher)

2. Determining the location of an object

The weavers determined the position of various tool and equipment used in the weaving process. *Pola* was placed parallel with *Wititara* with the distance between the two of them is 4-5 spans for *kewatek* and 5-7 spans for *nowi*. Weavers choose the appropriate yarn colors and placed them on the appropriate yarn lane. Weavers also determined and placed the motifs at equal distances from each other in the appropriate yarn lane. Different motifs were placed on a different but parallel yarn lane. Along each yarn lane, it appeared that the weavers had a concept of equidistance, symmetry, translation, and rotation.

3. Measuring such as measuring the width and length of *kewatek* in spans.

Be'len noon bela'han ne kame ukur nuda bela'han ne. kame mabe wage, biasa naen kewatek ne be'len wage paat ta' di lema nage bela'han wage telo raine, nowi be'len wage lema sampe pito ge bela'han wage telo raine
(The width and length of cloth is measured by us on the length of *nuda* using span. The width of *kewatek* cloth was usually 4-5 spans and the length was more than 3 spans [for one piece so that the whole length of *kewatek* was 7 spans], while for *nowi*, the width was 5-7 spans and length was more than 3 spans so that the total length was 7 spans).

The measuring activity also appeared in estimating the magnitude of cotton rolls (*Lelu*) and spools (*udu*) namely **the size of a grip**. Weavers measured using nonstandard measures such as **handgrip and hand span** although weavers were already familiar with standard measuring tools such as ruler or meter. For weavers, using a ruler or a meter was inconvenient as measuring errors could occur.

*kame mabe wage be pelohun. Kame maan be mistar haka dai ne hala... ne helen be repoten...matat mete medo toi uli wana hala hae...(*We use to use the span. We do not use a ruler or a meter, it's too much bothering... the eyes are old, we are afraid to make a mistake *...)*

The weavers also **compared** the yarn spindle between past and present, and compared selling price among woven cloths.

... nolhon kae kewatek to'u ne benang ko'ten pulo raine hena, naku nuan murine ni benang ko'ten mete kuse ke aem pulurua raine. Turun benang ko'ten mete kuse ke mian kame pudun udu ne kame gute ko'ten rua ge pudun maan udu tou (... in the past one *kewatek* needed not more than 10 bonds of yarn, but now because of the smaller bond then one *kewatek* needed more than 20 spindles. Since the yarn spindle is smaller then we take two spindles and roll them into one yarn spindle-*udu).*

Regarding the selling price, the weavers mentioned that if they were offering their woven fabric, the prices would be cheaper. Conversely, if a buyer is looking to buy then the prices are set according to market prices. In this context, we argue that the weavers seemingly understood the concepts of supply and demand as they priced their merchandise.

4. Designing,

The weavers selected the type of cloth to be woven, created the color pattern that would be used, and designed a motif as an expression of harmony with the natural environment. The type of motif was generally made by replicating an existing motif. The weavers had already been more creative in making other motifs such as the motif of *karo lolon* (leaf), *muko kena'lan* (banana slices), *kuku beak* (butterfly), trophies, and a combination of several motifs. Weavers were also creative as they designed motifs with different sizes, so the woven cloth looked nicer and more attractive.

5. Explaining,

The weavers described clearly the various types of *kewatek* and the motifs used the relationship between the type of *kewatek* and its selling prices, and the process to produce yarns from cotton. Weavers had a good and thorough understanding of the weaving activity and had a high degree of accuracy in the entire weaving process including designing and making the motifs.

6. The use of implication logic

The causal logic (if ... then) in weaving activity could be seen from the verbal expression of the weavers as they used the phrase ***naku ... neti.***

Weavers generally knew how much the spun yarn required for a woven cloth based on their experience. One bond of spun yarn consisted of 10 same color yarn. Buyers did not have to buy one bond of yarn. They could buy less than 10 spinning as needed. If the buyers bought yarn less than 10 then the price varied.

Kame hope (benang) ne koten pulo ra puin raan tou ne welin ribhun puloklema, ***naku*** *kame hopi telo* ***neti*** *ribu lema, kame hope rua* ***neti*** *ribu paat.* (In one bundle of yarn, there are 10 small bonds. We buy it fifteen thousand rupiah, but if we buy 3, the price is five thousand rupiah, and if we buy four, it costs four thousand rupiah).

In connection to the selling price, weavers said that the selling price might vary depending on who had the initiative first in selling or buying. If a buyer is looking to buy then the prices are according to market prices. Conversely, if a weaver offered the woven cloth to be purchased, the price is slightly cheaper than usual. Here it was clear to us that the weavers applied the concepts of supply and demand.

Nowi ne welin ribhun teratu puluruo noon lema, ne kalau ata rabe dahan. ***Naku*** *tite tabe sawa ata hope ne,* ***neti*** *bisa welin ribhunteratu noon puloklema ta'pe ribhunteratu pulurua.*(the price of *nowi* is one hundred twentyfive thousand rupiah if buyers search to buy it. If we (weavers) are looking for people to buy, the price is one hundred and fifteen thousand rupiah or one hundred and twenty thousand rupiah)

Below is the *kewatek* cloth image with several motifs on it and used for further analysis.

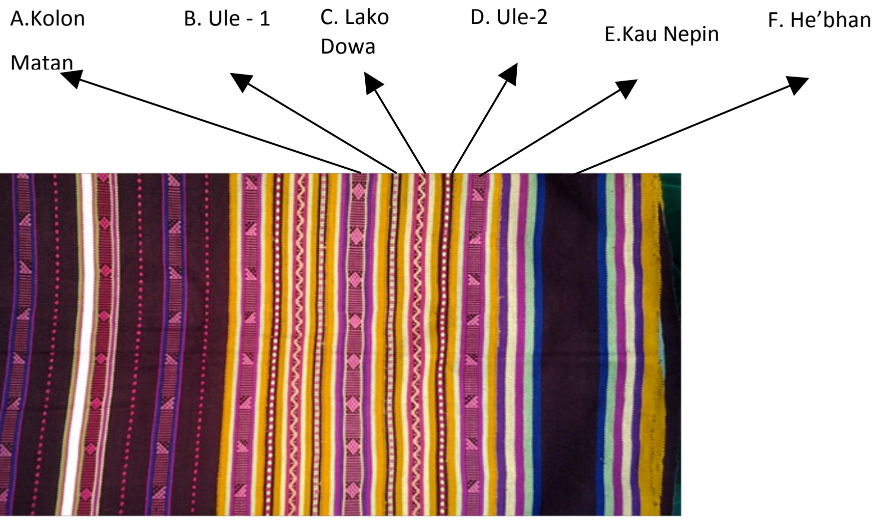

Figure 2. The Picture of *Kewatek Penetoten* cloth. (Photo by Reseracher)

In Figure 2, we describe the pattern colors and number of yarn on multiple motifs analyzed by the researchers. Each motif was taken from the part of *kewatek penetoten* cloth began and ended with a certain color. The piece of motif, the color of the yarn and the number of yarn in every color from left to right can be seen in Table 1 below.

Table 1
Motif of Kolon Matan, Yarn Color, and the Number of Yarn

	Yarn Colors (from left to right)	Number of Yarn
	white	8
	Pink	8
	purple	8
	white	3
	violet	2
	red	**7**
	violet	2
	white	3
	purple	8
	Pink	8
	white	8

K*olon matan* motif in the woven cloth above is a rhombus. This form was a change from the actual form of a bird's eye-shaped oval. This rhombic shape was formed by picking up the yarn with a certain configuration 1-2-3-4-3-2-1. The order of arrangement of the yarn forming this motif also formed palindromic numbers namely 1234321. This illustrated the skill of weavers to use oval shapes (bird's eye) prevalent in their environment and transfer as a motif in the woven cloth (rhombic). The weavers skillfully formed the motif using geometric symmetries. The number of yarn on this motif (column 3 of Table 1) written as 88832723888 is palindromic numbers. It is the same number when written forwards and backwards.

Table 2

Motif of Kau Nepin, Yarn Color, and the Number of Yarn

Part of *Kau Nepin* Motif	Yarn Color	Number of Yarn
	white	8
	Pink	8
	Violet	2
	red	**5**
	Violet	2
	Pink	8
	white	8

Kau nepin motif in woven cloth above was in the form of right-angled triangles. This form was similar to that of the shape along the midrib of the coconut leaf after the leaf palm was laid down. Right-angled triangular shape on the motif of *kau nepin* was formed by lifting the yarn with a certain configuration respectively: 3-2-2-1-1 or 1-1-2-2-3. This illustrated the skill of weavers to use geometric shapes (lying coconut leaves) prevalent in their environment and transfer as a motif in the woven cloth (right-angled triangles). The numerical representation of this motif (column 3 of Table 2) is 8825288, and this number is palindromic number.

From the analysis of the motifs described above, we concluded the following. *First*, the weavers had a concept of symmetry or the concept of reflection expressed in the phrase "**the same**" or "**balanced**" color and the number of yarn on the left and right of each motif.

Kame tao benang si nekin noon wana ne ***hamha*** *ti* ***hulen ne mela****, take neti mian papa bo bele papa be buse'* (We put the yarn on the left and right alike (color and number) so that it looks better, if it is not done, one side looks bigger than the other).

Second, the weavers knew the concept of ordering and grouping the yarn colors. Weavers set the color sequence regularly and adjusted the placement of the color group selectively so that it gave the interesting impression on the cloth produced. *Third*, there were geometric shapes such as rectangles (rhombi) and triangles (right triangles) with various characters. Rectangles and triangles displayed along the lane motif had regular intervals with a fixed shape and size. It also showed that the weavers had and used the concept of vertical and horizontal symmetry, translation, reflection, and rotation. *Fourth*, the weavers had the ability to determine, put and form motifs in *kewatek* cloth. We argue that a strong imagination is needed to transfer images in the environment to motifs executed on the woven cloth. *Fifth*, determining the use of the color of the yarn and the number of yarn bundle on each yarn color indicated the weavers' skill of mentally calculating and remembering the count without resorting to writing.

Implications of the Study

This study showed that there are a number of mathematical ideas inherent in the weaving activity. Such ideas include counting, addition operations, measuring, logic implication, rhombic, triangles, parallel lines, vertical and horizontal symmetry, rotation, reflection, and translation. The Adonara people have already the technology for conducting a rather complicated weaving activity. They perceived the tools used in the weaving activities as the most essential instruments needed to complete the desired outcomes.

We argue that the weaving activity can be utilized as a learning context for teaching basic mathematics concepts. Using woven fabrics as learning media makes learning more contextual and helps build awareness of fact that mathematics is manifested in cultural artifacts and practices (e.g., weaving activity).

The use of cultural artifacts to facilitate mathematics learning is a conscious and systematic effort in preserving culture and in broadening views of what counts as mathematical knowledge. Further research is needed to explore the development of new culturally based mathematics learning models.

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References

Ascher, M., Ascher, R., (1997), *Ethnomathematics*, In A. Powell & Frankenstein M. (Eds.), Ethnomathematics, Challenging Eurocentrism in Mathematics Education (pp. 25-50), Albany: NY, State University of New York Press.

Alangui, W.V., (2006, February), The *mutual interogation as an ethnomathematical approach*, 3 rd International Conference on Ethnomathematics, Auckland, New Zealand.

Barton, W.D.,(1996), *Ethnomathematics: Exploring Cultural Diversity in Mathematics*, Dissertation, The University of Auckland.

Begg, A.,(2006), the *Ethno*-Mathematics*, Ethno-Knowledge, Ethno-Education*, ICME-3, the International Congress on Ethnomathematics, Auckland, February 2006, pp. 1-10.

Bishop, A.J., (1988), The Interaction of Mathematics Education with Culture, *Culture Dynamics 1988*: 1; pp. 145-157. DOI: 10.1177/92137408800100200.

D'Ambrosio, U., (1997), *Ethnomathematics and its Place in History and Pedagogy of Mathematics*, In A. Powell & Frankenstein M. (Eds.), Ethnomathematics, Challenging Eurocentrism in Mathematics Education (pp. 13-24), Albany: State University of New York Press.

D'Ambrosio, U., (2001a), What is Ethnomathematics, and How Can It Help Children in Schools?, *Teaching Children Mathematics*, Feb., 2001, V7 (6), pp.308-311.

D'Ambrosio, U., (2001b), *Ethnomathematics: Link Between Traditions and Modernity*, Publisher sense, Roterdam-Netherlands.

Dominikus, W.S., Nusantara, T., Subanji, & Muksar, M., (2016), Link Between Ethnomathematisc in Marriage Tradition in Adonara Island and School Mathematics, *IOSR Journal of Research & Method in Education (IOSR-JRME)*, Volume: 6, Issue: 3 (version-IV), pp.56-62, DOI:10.9790/7388-0603045662.

François, K., (2012), Ethnomathematics in a European Context: Towards an Enriched Meaning of Ethnomathematics, *Journal of Mathematics & Culture*, ICEM Focus Issue 4, pp.191-208.

Gerdes, P., (2014), *Ethnomathematics as a New Research Filed*, *Illustrated by Studies of Mathematical Ideas in Africa History,* www.ethnomathematics.org/articulos/gerdes.pdf , Download on 22-2-2014.

Horsthemke, K., Schäfer, M., (2007), Does 'Africa Mathematics' Facilitate Access to Mathematics? Ongoing Towards Critical Analysis of Ethnomathematics in a south Africa Context, Pythagoras *65*, 2007, pp. 2-9.

Liliweri, A., (2014), *Pengantar Studi Kebudayaan*, Nusa Media, Bandung.

Meaney, T., Fairhill, U., Trinick, T., (2008), The Role Language in Ethnomathematics, *Journal of Mathematics & Culture*, June 2008, V3 (1), pp. 52-65.

Milroy, W.L., (1992), An Ethnography Study of The mathematics Ideas of a Group of Carpenters, *Journal for Research in Mathematics Education*-Monograph, No.5, National Council of Teachers of Mathematics, USA.

Nunes, T., (1992), *Ethnomathematics and Everyday Cognition*, In D.A. Grows (Eds.), Handbook of Research on Mathematics Teaching and Learning, pp.557-574, New York: MacMillan.

Presmeg, N., (2007), *The Role of Culture in Teaching and Learning Mathematics*, In Frank K. Lester (Eds.): Secon Handbook of Research on Mathematics Teaching and Learning: A Project of The National Council of Teachers of Mathematics, pp.435-458, information Age Publishing, New York.

Sanga, F., (2004), *Bilangan Pokok Dalam Konteks Budaya,* Study of Symbolic Interaction Perspective Etnonumerologi in Lamaholot Society in NTT, Dissertation, University of Airlangga, Surabaya.