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Ethnomathematics in *Buna-Insana Motif* Weaving Activity and its Link to School Mathematics

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ABSTRACT

This study explores ethnomathematics in the activity of weaving *Buna-Insana* motifs and its connection to school mathematics using an ethnographic case study with weavers from Botof Village, Insana District, guided by Bishop's ethnomathematics concepts: counting, measuring, designing, and reasoning. The results of the study indicate that the counting activity, mathematical knowledge in the form of addition operations is obtained. The measuring activity, hand spans are used as a unit of measurement. In the designing activity, the motifs produced are related to plane geometry concepts and similarity concepts. After the designing activity, reasoning activities are carried out. Implication logic is also found in weaving activities, namely when determining the selling price of woven fabrics and the length of weaving time.

1. Introduction

As one part of formal education, mathematics education plays a role in preserving culture and instilling cultural values and developing the nation's culture. This is in line with the opinion of Risdiyanti & Prahmana (2020) that mathematics education needs to contextualize mathematics with the environment and culture of students because, in essence, science arises from the needs and expectations of community members in a particular culture to respond to the environment and answer various problems faced in their lives. For this reason, cultural studies from mathematics are needed because mathematics is a

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construction of the culture itself. Cultural studies from the aspect of mathematics are known as ethnomathematics. One that can bridge education and culture, especially mathematics education, is ethnomathematics (Rosa & Orey, 2016).

Ethnomathematics means the study of the relationship between mathematics and the emerging cultural knowledge of a member of a cultural group (Silva et al., 2022). Currently, ethnomathematics has become a field of research focused on the relationship between culture and mathematics. Ethnomathematics aims to use diverse examples to solve problems from various cultures and recognize that learning mathematics is a unique process for each individual. Ethnomathematics will differ depending on the cultural environment (Dominikus, 2021).

Ethnomathematics broadly uses mathematical concepts related to various mathematical activities. Bishop identified six universal mathematical activities found in every cultural group: counting, locating, measuring, designing, playing, and explaining – CLMDPE (Bishop, 1988). These six activities form the basis for the development of mathematics, which is then known as the characteristics of ethnomathematics (Mukhopadhyay & Greer, 2011; Shirley, 2006)

Several studies related to ethnomathematics have been conducted with different focuses. These include traditional musical instruments, games, artifacts and crafts, language, wedding traditions, and work or workplace (Aini et al., 2019; Astria & Kusno, 2023; Dominikus et al., 2016b, 2016a; Febriyanti et al., 2019; Hidayatulloh & Hariastuti, 2018; Utami et al., 2019; Zayyadi, 2017). In addition, several of studies related to the application of ethnomathematics have been conducted in mathematics education (Disnawati & Nahak, 2019; Nurbaeti et al., 2019). The research results of Novitasari et al., (2022) also stated that the use of ethnomathematics-based student worksheets with an effective STEM approach improves students' critical thinking skills. All the research results expressed above state that the mathematical elements obtained can be used in mathematics learning

Other studies that used the woven fabric of the Dawan-Timor tribe as a research subject were Disnawati & Nahak (2019) develop student worksheets based on ethnomathematics of Timor woven fabric on number pattern material. Deda & Disnawati (2017) has examined the relationship between the woven fabric of the Dawan-Timor tribe and mathematics in schools. As well as research conducted by Deda & Disnawati (2019) has developed ethnomathematics-based student worksheets (LKM) using the context of Timor woven fabric motifs. The above studies also examine ethnomathematics in Timorese woven fabrics, but the research context is directly related to woven products used to design LKS and LKM. No researcher has specifically examined the weaving activity of the *buna-Insana motif*.

The Dawan tribe in North Central Timor Regency, East Nusa Tenggara, consists of three tribes in three swaprajas: Biboki, Insana, and Miomaffo (Biinmafo). Weaving (*nteun*) for the Dawan community is a routine activity carried out since long ago and is a legacy of the ancestors that is still being carried out and maintained by the local community, especially the village community (Utomo et al., 2023). One of the woven motifs in the Dawan-Timor tribe is the *buna motif*, which the people of Insana District usually weave.

Ethnomathematics can facilitate students' construction of mathematical concepts with the initial knowledge they already have because of their environment. One way to achieve this is through weaving activities, which are

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part of the local content curriculum in schools. Previous research has shown that woven fabrics can serve as an effective medium for teaching mathematics. Risdiyanti & Prahmana (2020) emphasize that mathematics learning should begin with real contexts derived from the sociocultural and reality around students.

So far, there has been no research related to weaving activities associated with school mathematics, so this research was conducted to describe the mathematical content contained in the *Buna motif* weaving activity, which includes the tools used, motif design, weaving process, and marketing of woven fabrics and then relate it to school mathematics. The math content includes numbers, algebra, measurement, geometry, data analysis, and chance. The activity of weaving *buna motifs* was chosen because weaving activities began to be included in local content subjects, so it is essential to educate students, teachers, and the community that mathematical activities are indirectly often done and experienced.

2. Method

This study aims to determine the relationship between Buna motif weaving activities and school mathematics. This research is qualitative research with an ethnographic design. Creswell (2012) defines ethnography as a qualitative research procedure that describes, analyzes, and interprets parts of a cultural group gathering, such as behavior patterns, beliefs, and language that develop over time. So, the ethnographic design was chosen for this study because it is to the problem and research objectives. With ethnographic design, the weaving activity of Buna motifs can be described, and then the mathematical knowledge contained in the weaving activity can be defined according to the characteristics of ethnomathematics expressed by Bishop. This is based on the idea that every weaving activity in a tribe/region or type of woven fabric has different knowledge (mathematical knowledge) according to its needs (Dominikus, 2021).

The subjects in this research were a group of weavers who live in Botof Village, Insana District. The main instrument in this research is the researcher, who is equipped with supporting instruments such as observation guides, interview guides, voice recorders, video recorders, and image recorders. This research collected data in the field using non-participatory observation, in-depth interviews, photographs, and audio/video recordings. The data collection process began with non-participatory observation of the weaving activities carried out by the research subjects that had been determined previously. In this non-participatory observation activity, the researcher is in the environment to observe what the research subject does while making field notes and taking photos/videos.

The data concerning Bishop's ethnomathematics characteristics were analyzed to identify, collect, and describe various mathematical knowledge in weaving activities. However, it does not rule out the possibility that researchers also find other findings. All of these findings will be described in detail so that mathematical knowledge can be clearly known in the activity of weaving buna motifs. Furthermore, the relationship between ethnomathematics content in weaving activities and school mathematics content is also analyzed to describe the relationship between ethnomathematics in buna motif weaving activities and school mathematics.

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3. Results and Discussion

This section describes the research findings on mathematical knowledge in the weaving activities weavers perform. In these activities, weavers engaged with mathematics in their daily lives. The final part will elaborate on the relationship between ethnomathematics in weaving activities and school mathematics, particularly at the junior high school level.

3.1. Mathematical Knowledge in Weaving Activities

For Dawan-Timor women, weaving was initially an activity to fill their free time. The weaving skills they possess have been naturally passed down from generation to generation (Utomo et al., 2023). Over time, woven fabrics have gained commercial value, and weaving has become a livelihood for many. In the past, woven fabrics were used solely as body coverings, clothing for traditional ceremonies, bride price exchanges in marriage traditions, death rituals, and other customary events. Woven fabrics are used today to make suits, ties, decorative materials, souvenirs, dresses, skirts, and uniforms. As a result, woven fabrics now hold both economic and social value.

Based on interviews with weavers, weaving activities generally consist of two stages: the thread production stage and the fabric production stage. In the thread production stage, weavers currently rely on the available thread, which is sold for IDR 2,500 per spool. The type of fabric used among the Dawan-Timor community varies depending on the weaving technique. Three types of woven fabrics are *Futus* (*ikat* weaving), *Buna*, and *Sotis*. These three types of fabrics differ in weaving techniques and the methods of creating motifs. Additionally, the fabric used for men is commonly referred to as *bete* or blankets, while the fabric for women is called *tais* or sarongs(Utomo et al., 2023). In the use of *bete* and *tais*, a complementary fabric is commonly used, known as bet'ana or a shawl.

The *Buna* motif woven fabric is one of the motifs frequently crafted by weavers in the Insana region. The *Buna* motif is a distinctive feature and a cultural heritage of the Insana community. Weavers typically purchase threads sold in markets at prices ranging from IDR 2,000 to IDR 2,500 per spool. Two threads are used: wood thread as the base color thread and silk thread for creating the *Buna* motif (Figure 1a). Wood thread is priced between IDR 17,500 and IDR 20,000. Producing one requires approximately ten spools of wood thread, while the amount of silk thread depends on the number of *Buna* motifs to be created.

In the initial stage, the weavers manually roll the threads into hand-sized spools (Figure 1b). Weavers generally avoid using tools for rolling threads to maintain flexibility, allowing the process to be done anywhere. The rolled threads are then arranged on the loom in a stage called *non*. After *non*, the weavers form the *Buna* motif by tying colored silk threads onto the base threads. The choice of colors typically depends on the preferences of buyers or clients. The color selection is based on the weaver's creativity if there are no specific buyers or orders. Generally, the *Buna* motif is created using six colors in addition to the base color. Figure 1 illustrates the threads used for weaving.

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Figure 1a. A single spool of thread

Figure 1b. The thread that has been rolled

Figure 1. Threads used for weaving

When creating *buna motifs*, the weaver first determines the motif's size according to the fabric type to produce. The more intricate and dense the *buna* design, the more thread is required. At the beginning of the process, the weaver selects the color combination to create the *buna*. The production begins by manually tying the colored threads onto the base threads. It takes 60 rows of inner threads (*monaf*) to form a *buna motif*, after which the subsequent rows repeat the pattern of the first 60 rows. This repetition continues until the motif is fully formed at the end of the threads. The weaving process for the *buna motif* is shown in Figure 2 below.

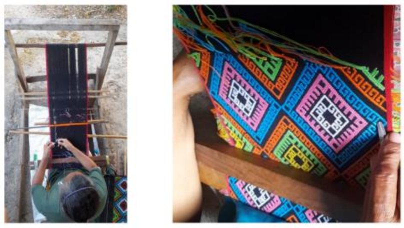

Figure 2. The Process of Weaving the *Buna* Motif

The *buna* motif consists of *manoeb* and *mabata* motifs (Natun et al., 2021). *Manoeb* comes from the Dawan language (a regional language in Timor) and means "interconnected." This indicates that the motif is continuous, with no gaps, and seamlessly links together. In contrast, *mabata* features spaced motifs. Fabrics with *buna manoeb* and *buna mabata* motifs are of the same size. The motifs in *Buna Manoeb* symbolize community unity and the interconnectedness of individuals. This interconnectedness is evident in the *mak'aif*, which intertwine with one another.

3.2. The Relationship Between Ethnomathematics in the Weaving Activities of the Dawan Tribe and School Mathematics

In the entire weaving process, mathematical knowledge can be identified and explained based on Bishop's ethnomathematics characteristics, as follows:

3.2.1. Counting

Counting activities are performed to determine the number of threads in each row and to create motifs during the thread-dyeing process. The number of threads is never written down but instead memorized. Similarly, when tying the threads (*non*) to form motifs, the fabric's pattern is never drawn but only remembered and visualized mentally or replicated from existing weaving patterns. This indicates that calculating thread count and color arrangement for fabric motifs relies heavily on the weaver's memory, experience, and references to existing woven fabrics.

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The number of threads required in weaving depends significantly on the number of *buna* motifs created or the type of fabric being produced, such as this, *bete*, or *bet'ana*. In this study, weaving *bet'ana* (which includes two *buna* motifs) requires two rolls of black thread for the base and inner threads (*monaf*), as well as colored threads in green, orange, yellow, pink, blue, and white, each amounting to two spools.

The number of threads required to weave *Bet'ana Buna Insana* can be observed in the following excerpt from the interview (R : researcher; S : Subject) :

R : For the *bet'ana* weaving, how much thread is needed?
S : For the *bet'ana*, we use two spools of black thread for the base and *monaf*. Then, for the colored threads used in the *buna* motif, we need two spools for each color. Additionally, red thread is used for the edges, requiring two spools.

Based on the interview excerpt above, it can be written in a mathematical sentence as follows:

2 rolls of black thread + 2 spools of green thread + 2 spools of yellow thread + 2 spools of orange thread + 2 spools of blue thread + 2 spools of pink thread + 2 spools of white thread + 2 spools of red thread = 16 spools of thread

The addition operation performed to weave tais, as represented in the mathematical sentence above, shows that when determining the number of threads for each color, the weavers perform addition as an abstraction of the number of threads in each color. In addition to numbers and addition, there is the concept of sets and subsets. The set is the collection of threads used to weave this, while the subsets are the colors of the threads used, which include black, red, green, orange, yellow, pink, blue, and white. In the counting activity, there is an operation related to addition. This activity involves adding elements from two different subsets of the same set. For example, six spools of red thread + two spools of green thread = 8.

Mathematically, the example above shows a difference when related to algebraic concepts in school. Six spools of red thread + two spools of green thread = 8 spools of thread; when written in algebraic form as 6m + 2h = 8, where m represents red thread and h represents green thread, this algebraic form is incorrect. In algebra, variables represent numbers; adding algebraic terms only applies to like terms. Therefore, while students can learn concepts like sets, subsets, set operations, and number addition through the weaving activity, it may also confuse students when learning algebraic addition in school (Dominikus, 2021).The relationship between counting activities in weaving culture and school mathematics is shown in Figure 3 below.

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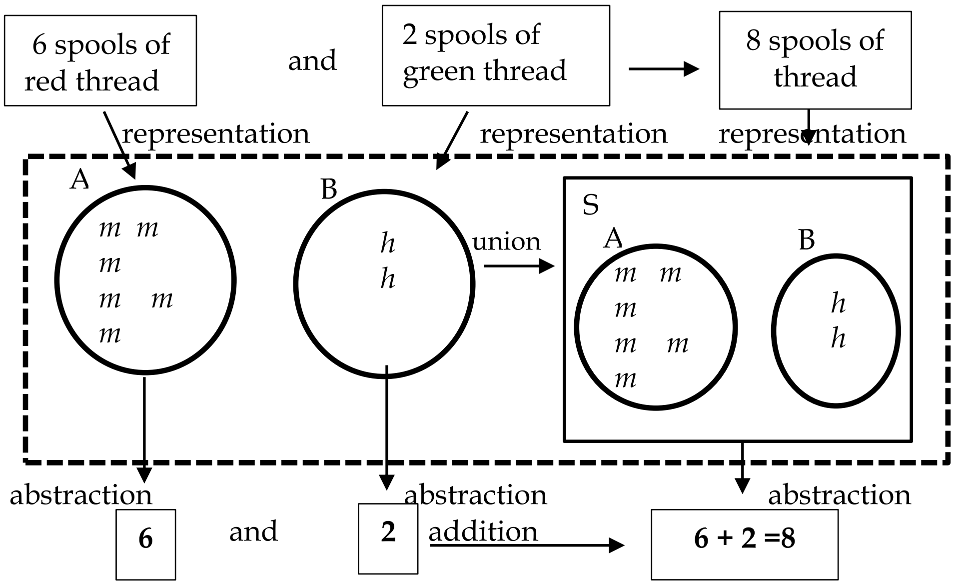

Figure 3. The Relationship Between Counting Activities in Weaving Culture and School Mathematics

The notations used in Figure 3 are description as follows:

Table 1. Notation Description

Notation	Description
A	{red thread used for weaving}
B	{green thread used for weaving}
S	{the set of thread colors used for weaving}

Figure 3 shows that in the counting activity, there are concepts of sets, subsets, set operations, addition operations, and processes of representation and abstraction. The representation process is marked by expressing the number of red and green threads and the total number of threads in set notation and set operations. On the other hand, the abstraction process is shown by expressing six spools of red thread as the number 6 and 2 spools of green thread as the number 2, then performing the addition operation: 6 + 2 = 8. Abstraction in this context means ignoring other aspects of the actual object and focusing only on the quantity or number of actual objects present (Nunes, 1992). In this case, the different colors of the threads are disregarded, and attention is focused only on the number of red or green threads.

3.2.2. Measuring

Measuring activities generally relates to "how much" (length, width, height, duration, quantity). The measurement tools used in weaving activities are typically the fingers and hands. For instance, the standard size of woven fabric (*tais*) used by weavers is six hand spans in length, and five hand spans in width. Meanwhile, the typical size for a bete is eight hand spans in length and six hand spans in width. These measurements can change depending on customer requests or the buyer's body size.

Measuring is also seen in determining the size of thread spools, typically measured by the fist size. Weavers do not use standardized measurements but

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rely on customary sizes or measurements they frequently use. Teachers do not use non-standard measurements like those described above in classroom learning, even though measuring activities carried out outside the classroom like this provide students with real experience in learning mathematics. These experiences increase students' interest in learning when integrated into school lessons. Rosa & Orey (2006) suggest that incorporating cultural and daily experiences into teaching school mathematics, particularly measurement concepts, can be highly beneficial in fostering meaningful learning.

3.2.3. Explaining (use of implication logic)

In weaving activities, logic is applied in various aspects, particularly in determining the duration of weaving and the sale of woven fabric, as explained below:

a. Duration Required to Produce a Piece of Fabric

   The time required by a weaver to produce a piece of fabric is expressed in months, where 1 month consists of 30–31 days. The daily weaving process is accumulated into months. Based on interviews and observations, no weaver calculates the duration in hours instead of days, summed into months, as understood by the weavers. Even if weaving is done for only a few hours daily, it is still counted as one full day.

   In the weaving process, implication logic is used. This logic is evident in the duration of weaving and the sale of woven fabrics. The complexity of the motif produced affects the weaving time. Additionally, weavers explained that interruptions or other activities, such as mourning periods or family events, influence the weaving duration they must attend to. If there are interruptions, the time required for weaving becomes longer. In this study, each weaver typically requires approximately three months to complete a piece of fabric.

b. Selling Price of Woven Fabric

   Generally, a single tais is sold at a price ranging from IDR 2,500,000 to IDR 3,500,000. This selling price represents the typical market rate. For weavers, the most critical aspect of selling their woven fabric is that the generated income can meet daily needs, support children's education, and purchase more thread for future weaving.

   The selling price of woven fabric may vary depending on the seller's or buyer's needs. The price will align with the market rate if the buyer urgently requires the fabric. However, the price may decrease if the weaver or seller needs funds and decides to sell the fabric.

3.2.4. Designing

In the woven fabrics of the Dawan tribe, there are several fabric motifs and processes for creating these motifs, which generally share similarities. In this study, the *buna* motif produced takes the shape of a rhombus; however, the weavers do not know the exact origin or the historical story behind the motif. The weavers continue the existing motifs and were commonly made by their ancestors.

To create the *buna* motif, the base threads are tied using colored threads. The quantity of buna produced is adjusted to the size of the *tais* or *bete* (traditional

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fabric types) to be created. The *buna* motifs produced are continuous and identical in shape. The large rhombus shape is formed by tying 101 rows of thread. The threads tied in each row vary to create the desired buna motif. The sequential thread tie design follows a pattern of 1-2-3-4-...-49-50-51-50-49-...4-3-2-1.

In addition to the large rhombus shape, there is a medium-sized rhombus within the large rhombus. The medium rhombus is formed by tying 65 threads. The thread tie design for the medium rhombus sequentially follows a pattern of 1-2-3-4-...-31-32-33-32-31-...4-3-2-1. Finally, a small rhombus is in the center, formed by tying 37 threads. The threads tied for the small rhombus follow the sequential pattern of 1-2-3-4-...-17-18-19-18-17-...4-3-2-1. This process reflects the intellectual and creative capacity of the weavers, who indirectly create rhombus shapes (geometrical patterns) in the woven fabric.


Figure 4. *Buna* Motif


Figure 5. *Buna* motif design

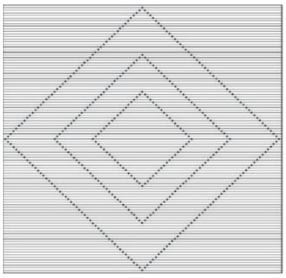
Figure 6. *Buna* motif representation

When observed closely, the change in size of the *buna* motifs—large, medium, and small—can be associated with the concept of similarity taught in junior high school mathematics. This can be seen in the length of each side of the *buna* motifs, which maintains a consistent proportional relationship, as well as in the corresponding angles, which are identical. For further clarification, please refer to the following illustration:

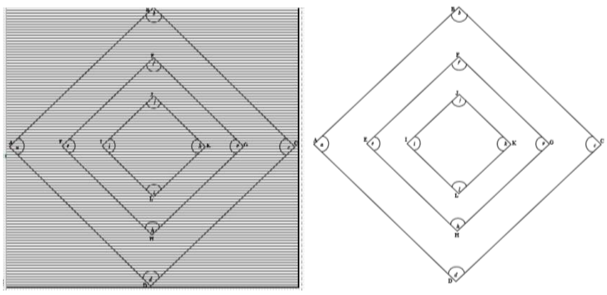
Figure 7. *Buna* motif in mathematics

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Based on the *buna* motif patterns described above, from the large *buna* motif (rhombus $ABCD$) to the medium *buna* motif (rhombus $EFGH$) and the small *buna* motif (rhombus $IJKL$), the properties of similarity can be identified as follows:

1) Assume that rhombus $ABCD$ is similar to rhombus $EFGH$, then
   a. The corresponding side lengths have the same proportional ratio, which is:
   $$\frac{AB}{EF} = \frac{BC}{FG} = \frac{CD}{GH} = \frac{AD}{EH} = \frac{51}{33}$$
   b. The corresponding angles are equal, namely :
   $$\angle A = \angle E; \angle B = \angle F;\ \angle C = \angle G; \angle D = \angle H$$
2) Assume that rhombus $ABCD$ is similar to rhombus $IJKL$, then
   a. The corresponding side lengths have the same proportional ratio, which is:
   $$\frac{AB}{IJ} = \frac{BC}{JK} = \frac{CD}{KL} = \frac{AD}{IL} = \frac{51}{19}$$
   b. The corresponding angles are equal, namely :
   $$\angle A = \angle I; \angle B = \angle J;\ \angle C = \angle K; \angle D = \angle L$$
3) Assume that rhombus $EFGH$ is similar to rhombus $IJKL$, then
   a. The corresponding side lengths have the same proportional ratio, which is:
   $$\frac{EF}{IJ} = \frac{FG}{JK} = \frac{GH}{KL} = \frac{EH}{IL} = \frac{33}{19}$$
   b. The corresponding angles are equal, namely :
   $$\angle E = \angle I; \angle F = \angle J;\ \angle G = \angle K; \angle H = \angle L$$

In addition to the weaving activity, geometric concepts are present in the shapes and motifs of woven fabrics. Plane shapes such as rhombus and similarity are evident in the weaving process. Thus, weaving activities and woven fabrics can serve as context and media for learning mathematics. Woven fabrics can be used to teach plane shapes and geometric transformations. This allows students to explore and discover the geometric concepts being studied.

Moreover, woven fabrics can help identify elements of plane shapes such as sides, vertices, angles, and diagonals. Students can also delve into the process of creating the materials and the cultural meanings associated with the media used. This aligns with Turmudi's, (2018) opinion that cultural artifacts can be used as a bridge for acquiring new mathematical knowledge taught in the classroom and expertise outside the school.

This approach allows students, individually or in groups, to interview community members with expertise as a learning resource, thereby actively involving the community in school mathematics learning. Additionally, students are encouraged to think critically and creatively, fostering communication and collaboration with the community and their peers during the learning process.

In summary, the connection between ethnomathematics in the weaving activities of the Dawan-Timor community and school mathematics concepts, as well as the scope of mathematics, can be summarized in the following table:

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Tabel 2. Connections Between Ethnomathematics in the Weaving Activities of the Dawan-Timor Community and School Mathematics

No	Ethnomathematics in Weaving Activities	School Mathematics Concepts	School Mathematics Concepts
1.	Counting	Sets, Set Operations, Algebraic Expressions, Arithmetic Operations	Numbers, Algebra
2.	Measuring	Standard and Non-standard Measuring Tools, Units of Measurement	Geometry and Measurement
3.	Explaining	Logic, Drawing Conclusions	Logic
4.	Designing	Plane Shapes, Similarity	Geometry and Measurement, Numbers

This table illustrates how ethnomathematics in weaving activities can be a rich source of context and inspiration in teaching mathematical concepts in schools. Dominikus (2021) research results also state that mathematical knowledge exists in weaving Adonara cloth. In woven fabric motifs, numbers, geometry, and symmetry patterns are found, which can be used as a mathematics learning medium. Vygotsky's theory (Zone of Proximal Development) shows that learning occurs more effectively in the student's cultural context. This research can encourage cultural integration in the mathematics curriculum to increase students' understanding of abstract concepts. This research enriches mathematics learning resources with local cultural context, promoting socially relevant education.

4. Conclusions

Based on the data presentation, data analysis, and discussion outlined earlier, it can be concluded that various mathematical knowledge exists in the weaving activity of the *buna-Insana* motif, referred to as ethnomathematics in weaving activities. Counting involves addition operations to determine the number of threads used for weaving. If linked to school mathematics, addition operations here are related to combining two or more subsets from the same set. This process also involves representation and abstraction. Such out-of-class counting activities provide students with real-world experiences in learning mathematics. These activities can be enriched and incorporated into various counting lessons in schools.

Measuring activities are associated with measuring tools like hand spans and fists. In school learning, measuring activities are related to standard units of measurement, such as length, weight, area, and others. Non-standard measurements are usually not taught in schools, but this could serve as input for teachers to utilize students' real-world experiences and link them to school material.

Designing involves the concept of plane geometry. Elements and concepts of geometry, such as points, lines, angles, parallel lines, and quadrilateral plane shapes, are found in woven fabrics. Properties of similarity are also present in weaving activities. These geometric concepts align with those used in mathematics teaching in schools. Thus, weaving activities can be used as context,

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media, and learning resources.

Logical implications are also found in weaving activities among the Dawan tribe. For instance:

a. The weaving process takes longer if disruptions include mourning, family events, or time spent farming.
b. In determining the selling price, the woven fabric price will be lower if the weaver initiates the sale. Conversely, the price will align with market rates if the buyer seeks the fabric.

Such reasoning in the weaving process relates to mathematical logic. Explaining is an activity that everyone engages in, anywhere and anytime. The cognitive activity of answering "why" is part of presenting and asking "why" in school learning, which is crucial for shaping students' reasoning and training them to think critically.

The above explanation demonstrates that integrating cultural elements into school mathematics learning benefits students by enabling them to construct their knowledge. Additionally, students are trained to develop collaboration and communication skills. Woven fabric can also serve as a medium for teaching corresponding geometry concepts. This research is only limited to North Central Timor district woven fabric motifs. This research also does not discuss the motifs on woven fabrics further, so in future research, we can discuss the motifs on woven fabrics in more detail.

Author Contributions

The first author served as the data collector, data processor, data analyst, and writer of the scientific article. The second and third authors provided feedback and suggestions for developing the study, analysis, and manuscript.

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Declaration of Competing Interest

The author stated that there was no potential conflict of interest in this research.

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