ETHNOMATHEMATICAL ASPECTS OF LEARNING GEOMETRY AND VALUES RELATED TO THE MOTIFS USED BY THE DAYAK NGAJU TRIBE IN CENTRAL KALIMANTAN

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ABSTRACT

Purpose – Ethnomathematics are used in motifs by the Dayak Ngaju Tribe in Central Kalimantan. The motifs contain some Ethnomathematical objects and concepts for Geometry and values. Therefore, this study aimed to describe the motifs based on mathematical objects and concepts of Geometry and value viewed from ethnomathematics aspects.

Methodology – This study used a qualitative approach with an ethnography method. The researchers collected information from documents and books. They conducted in-depth observations and interviews with the subjects regarding the culture of the Dayak Ngaju people who reside downstream of the Kahayan River in Central

Kalimantan. The subjects were a Dayak Ngaju craftsman and a priest of the Hindu Kaharingan community. The motifs consist of *tingang*, *dandang tingang, jata, batang garing, tanduk muang, buntut kakupu gajah*, *taya* tree and *rambunan tambun*.

Findings – The motifs contain some mathematical objects and concepts. Mathematical objects are created as circles, *batang garing* and *jata* motifs, and a six-sided shape in the *tanduk muang* motif. The concept is the geometric transformations, namely the $x-$axis reflection in the *mdandang tingang* and *tanduk muang motifs* the $y-$axis reflection in the motifs of *tingang*, *batang garing*, *tanduk muang* and *taya* tree. The 180^0 rotation on point (0,0) in the motifs of *buntut kakupu gajah* and *taya* tree, and the translation in the motif of *jata*.

Significance – The study provides some mathematical objects and concepts in the motifs of the Dayak Ngaju tribe in Central Kalimantan. Students learning those objects and concepts should be related to their culture, namely the motifs, and they should acquire the values in such learning. Ethnomathematics plays an important role among Dayak Ngaju people in understanding mathematics concepts such as Geometry and values.

Keywords: Batik motifs, Kalimantan, Dayak tribe, ethnomathematics, local wisdom.

INTRODUCTION

The education of the Dayak Ngaju people, one of the Dayak tribes in Central Kalimantan, Indonesia, should not be separated from their culture. The people have preserved their culture and customs under Indonesia's formal ethics and laws. If a problem occurs in the community, the *Demang* (chief) is in charge of overcoming it through mediation or decision-making. The customary law, such as *jipen*, applies consistently to the Dayak Ngaju people. In addition, local wisdom, one of the cultural elements, complies with the law regarding providing national education. The tribe's local pearls of wisdom are *pakat dayak* (values of cooperation, active participation, and tolerance), *utus* (values of identity), *pahewan* (values of preserving the natural environment), *manakir petak* (values of striving to achieve

success), *pantan* (values of openness to outsiders), *isen mulang* (values of persistence), *belom bahadat* (values of living ethically with the natural environment and the society), and *pintar tuntang harati* (values of being intelligent and well-educated) (Usop et al., 2012).

The local culture of the tribe has been reflected for a long time in motifs of batik, carvings, and paintings. One example of a beautiful and popular motif in Dayak Ngaju batik is *batang garing*. The motif resembles a tree and is believed to be an instruction for the Dayak Ngaju people (Usop et al., 2012). The values of the motif need to be explored and used as the basis for learning mathematics in the tribe since it contains mathematical objects and concepts.

Mathematical objects and concepts that exist in cultures have been studied for a long time in ethnomathematics. Ethnomathematics is defined as the acculturation between culture and mathematics. The learning emphasised in ethnomathematics is assumed to be more acceptable to most students. It is the culture existing in ethnomathematics that is inherent in the student's background and their societies. In addition, ethnomathematics makes learning more interesting since it applies real contexts in the locals' lives (D'Ambrosio, 1985; Risdiyanti & Prahmana, 2020).

Ethnomathematics research explores some fields of culture in several countries. In China, the Temple of Heaven in Beijing contains geometric shapes of a cylinder, a slice of a cone, and a circular cone. The temple interior has symmetrical properties. The building structure of the temple has four pillars inside to represent four seasons, and twelve pillars in the middle to represent twelve months in a year. The temple has three prominent colours. The colour red symbolises prosperity, blue represents the connection between humans and God, and yellow is the symbol of a king (Zhang et al., 2021). In Nepal, the height of the Machhindranath chariot is 32 hands long. The Machhindranath is the rain God in the local religion. The front of the chariot has two wheels, and both wheels can travel a distance equal to the height. Thus, the circumference of a wheel is 16 hands long, and number 32 represents a holy number (Pradhan & Sharma, 2021). Furthermore, there is a geometric transformation concept in the Hindu ritual of *Mandap* and *havankunda rekhi*, known as reflection, translation, and rotation (Parajuli & Koirala, 2022).

In Indonesia, cultural research by Yogyakarta researchers reported that mathematical modelling was used to determine the celebration of seasons and the date of birth or death (Prahmana et al., 2021). Primbon (the traditional Javanese manuscript) contains the concept of modulo and number bases (Utami et al., 2019). Moreover, the making of *barongko* (a delicacy in the Bugis tribe in South Sulawesi, Indonesia) demonstrates the concepts of division and geometry (prism, sphere, congruence, and similarity) (Pathuddin & Nawawi, 2021). In Sundanese culture, guessing, measuring, and making patterns involve ethnomathematics (Muhtadi et al., 2017).

Furthermore, some researchers in Indonesia have conducted ethnomathematics studies regarding motifs of the batik, carvings, and painting. Prahmana and D'Ambrosio (2020) reported geometric transformations in the production of Yogyakarta batik. Each of the motifs contains local wisdom related to leadership and virtues. Meanwhile, Ekowati et al. (2017) described that the Madurese batik motifs contain an ethnomathematical aspect, and the Madurese dance has a mathematical element that supports students in acquiring a meaningful understanding of numbers concepts. Another study by Irawan et al. (2019) described Balinese batik as containing geometric transformations and spiritual elements related to local cultural values.

Meanwhile, there are some ethnomathematics studies regarding the culture of the Dayak people in Kalimantan, Indonesia. Mangkin et al. (2021) had investigated the Dadas Bawo dance of the Ma'ayan Dayak tribe in Central Kalimantan. They found that the hand movements, footwork, and formations of the dance incorporate concepts of angles (acute, obtuse, and right angles), parallel lines, geometric shapes (triangles and circles), and geometric transformations (reflection, rotation, and translation). Another research by Dian (2021) on the Nugal tradition of the Sebaruk Dayak tribe in the Jentawang area, West Kalimantan, indicated that the tradition has some concepts of mathematical logic, sequences and series, geometric transformations (translation and reflection), and distances between points. Moreover, Eka et al. (2021) reported that the dominant mathematical concept of the marriage tradition of the Kanayatn Dayak tribe in Mempawah, West Kalimantan, is numbering. The idea appears when the traditional leader says, "*asa dwa talu ampat lima anam tujuh*" at the beginning of the *nyangahatn* (asking God) activities. The number *tujuh* (seven), which refers to "fulfilment", is the highest number in the tradition.

There are several studies on the cultural motifs and dances of the Dayak people in Central Kalimantan. However, there has been no study regarding ethnomathematical aspects of the motifs used by the Dayak Ngaju tribe as a product of local culture. Therefore, the statement of problems in this study is "What ethnomathematical aspects are related to the motifs used by the Dayak Ngaju people in Central Kalimantan, namely *tingang*, *dandang tingang*, *jata*, *batang garing*, *tanduk muang*, *buntut kakupu gajah*, *taya* tree, and *rambunan tambun*?" and "What values/local wisdom can be learned from the motifs?". The study results can enrich the results of the previous ethnomathematics studies on the Dayak tribe in Kalimantan, Indonesia, especially the Dayak Ngaju people. In addition, future researchers can develop an ethnomathematics-based learning model from the results.

RESEARCH METHODOLOGY

Research Approach

The characteristics of this research were as follows. It aimed to describe the ethnomathematical aspects of the motifs in batik, carvings, and paintings made by the Dayak Ngaju tribe in Central Kalimantan, Indonesia. It also explored the knowledge that is embedded within the culture or community of the tribe, namely the values contained in the motifs. The researchers conducted in-depth observations and interviews with two subjects, namely a Dayak Ngaju craftsman and a Hindu Kaharingan priest. The subjects were assigned through purposeful sampling to determine whether they had prominent information to the research questions. The data were photos, videos, interview transcripts, and field notes (qualitative data). Different data involved in triangulation were used to ensure the credibility and validity of the conclusion. Therefore, the researchers used a qualitative approach to ensure the credibility and validity of the result.

Data Collection

The data collection was divided into four essential questions. Firstly, "*Where to start looking*?". The researchers looked for the original motifs of the Dayak Ngaju tribe. Nowadays, some batik motifs in Central Kalimantan are mixed with other motifs from the Dayak tribe

in East Kalimantan or the Javanese tribe in Java Island. Some batik craftsmen, who have a sizeable market share in Palangka Raya, Central Kalimantan, are Javanese. Secondly, "*how to look*?". The researchers looked for information from old documents, the Dayak Ngaju craftsman, and the Hindu Kaharingan priest regarding characteristics of the Dayak Ngaju motifs. Thirdly, "*how to recognise significant findings*?". The researchers obtained a book from a famous Dayak Ngaju craftsman, Damang Salilah, whose name is commemorated as a street name in Palangka Raya, Central Kalimantan. The book's title is "*Aneka Ragam Ukiran dan Lukisan Dayak Ngaju Kalimantan Tengah* (A Variety of Carvings and Paintings of the Dayak Ngaju Tribe in Central Kalimantan)". The book was written circa 1973 and published in 1984. It explains the source of the Dayak Ngaju motifs and their descriptions. Fourthly, "*How do we understand the findings*?" The researchers asked the two subjects about the motifs' meanings and values described in the book. There were four main questions. They were "*What are the meanings of the motifs in the Indonesian language*?", "*what do the motifs symbolise*?" "*What are the values in the motifs*?" and "*How are the motifs drawn*?". The further questions were organised based on the subject's answers to the main questions.

The researchers studied the motifs and the culture of the Dayak Ngaju tribe. In general, the Dayak tribe is divided into seven significant tribes spread all over Kalimantan, namely, the tribes Ngaju, Apu Kayan, Iban, Klemantan, Murut, Punan, and Ot Danum. Each tribe is further divided into smaller tribes. Altogether, there are 18 small tribes in total. The small tribes are subdivided into 402 sedatuk (family) tribes (Kusni et al., 2011). Dayak Ngaju tribe consists of four small tribes: Ngaju, Ma'anyan, Dusun, and Lawangan. The number of sedatuk tribes for the four small tribes are 53, 8, 8, and 21, respectively. In other words, the Dayak Ngaju tribe is divided into 90 sedatuk. The researchers focused on exploring ethnomathematics in the motifs of the small tribe of Dayak Ngaju to investigate the relations between the motifs and mathematical objects. The Ngaju Dayak people reside downstream of the Kahayan River up to the village of Tumbang Miri in the Gunung Mas Regency, Central Kalimantan (Riwut et al., 2003).

The Dayak tribes share different languages, traditional items, clothing styles, and cultures even though they live close to each other (Kusni et al., 2011). Furthermore, traditional clothing and carving motifs were

adapted into batik clothes. The typical batik in the Dayak Ngaju tribe in Central Kalimantan is called *benang bintik* (white cloth painting). The motifs of *benang bintik* contain unique stories or moral values influenced by the belief of the Dayak Ngaju people, which is known as *Hindu Kaharingan* (Usop & Usop, 2021).

The *Hindu Kaharingan* is a traditional belief among the Dayak Ngaju people. The creation of the universe, humans, animals, and plants in their belief are narrated in the central legend of *Panaturan Tuntang Karak Tungkup* (The History of the Beginning and the End). Initially, only Ranying Hatala Langit (The One Almighty God) was with His shadow, *Bulan Bawi Jata Balawang Bulau*. With unlimited power, *Ranying Hatala Langit* and *Bawi Jata* filled the space of the horizon with long and loud lightning, creating two hanging hills, *Hintan Baraguntung* and *Bulau Baratu Yang Hawun*. The hills emitted bright rays of light to all corners of the universe. The seven collisions of the two hills created the universe, and everything in it, including a very lush giant tree called *batang garing* (tree of life) (Riwut et al., 2003).

Research Subjects

The first research subject was a Dayak Ngaju craftsman, and the second subject was a *basir* (priest) of the Hindu Kaharingan community. The researchers selected a *basir* as one of the subjects since the Dayak Ngaju motifs, including their values, are influenced by the Hindu Kaharingan. In addition, the two subjects were selected based on two criteria. Firstly, the subjects were over 50 and had over 20 years of experience in their respective fields. Secondly, the subjects were the original descendants of the Dayak Ngaju people, fluent in the tribe's language, and spent most of their lives in their community in Central Kalimantan. The purpose of determining the criteria for information about the motifs and their values is credible and firmly rooted in the Dayak Ngaju culture.

The first subject, coded as "S", 67, is a Dayak Ngaju craftsman. He is the grandson of Damang Salilah, the famous Dayak Ngaju craftsman. He had learned *batik*, carving, and painting since elementary school. It means that he had approximately 50 years of experience. He had spent most of his life in Palangka Raya, Central Kalimantan.

The second subject, coded as "B", 53, is a Hindu Kaharingan *basir*. For this study, he was recommended by the Head of the Hindu Kaharingan Great Council in Central Kalimantan. His father was also

a *basir*, and his parents are the Dayak Ngaju tribe members. He had 28 years of experience as a *basir*. He also spent most of his life in the Dayak Ngaju community.

Data Analysis

The researchers analysed the data in six stages. In the first stage, they transcribed the interviews and organised the observational data according to their characteristics or sequences. In the next stage, they removed the irrelevant data. Subsequently, they coded sentences on the transcripts. Afterwards, they triangulated the data by checking the credibility of the results of the interviews and the documents. If data from different methods show similar characteristics, the data is proven credible and valid (the triangulation method). In the fifth stage, the researchers conducted peer review and participant feedback by asking colleagues and the subjects to examine the data and the results. In the final stage, they interpreted the data by analysing the interview transcript's phrases, words, and sentences. They looked for similarities in the characteristics of the data. As a result, the data with the same characteristics is the ethnomathematics in the Dayak Ngaju motifs.

The codes used in the research are six-digit combinations of letters and numbers. The first digit is a letter indicating the subject's code (S or B). The second and the third digits are in the form of letters, indicating the motifs. The codes comprise MB (the motifs), JT (*jata*/dragon), TG (*tingang*/hornbill), DT (*dandang tingang*/hornbill's rectrix), BG (*batang garing*/tree of life), HL (other animals), and PL (other trees). The fourth to sixth digits are numbers, indicating the sentence order in the interview transcripts (sequence of 001-999). For example, code STG035 symbolises the sentences from subject S. The sentences contain information about the motif of the *tingang*. The sentences are in order 35. The coding is helpful for sources and time triangulations. A conclusion is based on the sentences in the interview transcripts with codes STG035 and BTG020. Thus, the conclusion came from two subjects (the sources' triangulation). In addition, a conclusion with codes STG035 and STG077 indicates that the same subject in two different times (different order) stated similar characteristics (the time triangulation). Therefore, the researchers used three aspects of triangulations, namely source, time, and method, to ensure the credibility/validity of the results.

RESULTS

The Motifs of Dayak Ngaju in Central Kalimantan

The motifs of Dayak Ngaju are the combinations of the motifs of *batang garing*, *tingang*, *dandang tingang*, *jata*, animals and plants. The drawing process of the motifs followed several principles. First, each motif has its own stories and values. Subject S said: "… before he (Damang Salilah, the grandfather of subject S) drew, there should be a title. He could not draw without a title. The title should be relevant to the stories in the motifs" (SGB001). Second, the drawing started from a point followed by curves and straight lines (SGB001; SGB005). Subject S said: "… that is why when he drew *tingang* from the head to the tail, he must put a dot here and there to maintain a straight position. The tail is here, and the head is there. The intention is to control the space that has been given" (SGB005). Third, subject S said: "If the motifs are repeated to the right, surely they also are repeated to the left, like this" (SGB001). The first principle that appeared in every Dayak Ngaju motif has stories or values. The second and third principles can be seen in repeated shapes in the hand paintings made by Damang Salilah in 1973. The repeated shapes indicate the geometric transformation concept.
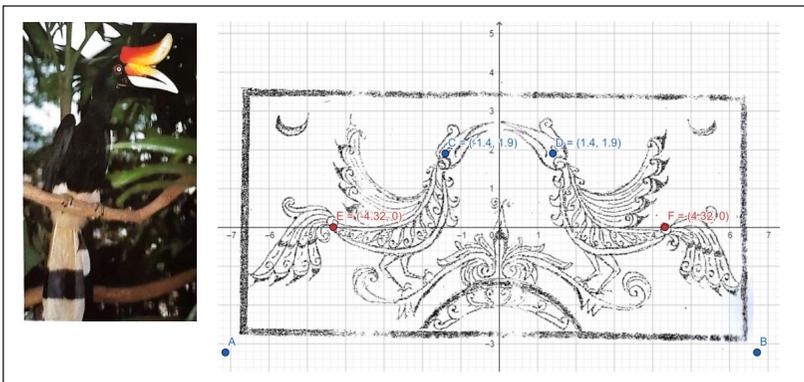
The Tingang Motif

Tingang or rhinoceros hornbill (*Buceros rhinoceros*) symbolizes glory or holiness. The Dayak Ngaju people believe it was the first creation of *Ranying Hatala Langit*, who is responsible for caring for the lives (interview transcripts with codes STG004, STG062, STG084; BTG001; BTG030). The conclusion had been triangulated by source (from two subjects) and time (same subject with a different order, such as STG004 and STG062). The height of a *tingang* can reach 120 cm (Davison & Fook, 2008), which makes them the enormous birds in Central Kalimantan and thus symbolise greatness (BTG001). The birds usually fly high and perch on the tallest tree (MacKinnon et al., 2010), thus symbolising power (BTG001). The conclusion had been triangulated by method since it came from the textbooks and the interviews. The birds' sound is the loudest and most distinct (STG064; BTG001), such as the horn "honk-hank..." (Davison & Fook, 2008; MacKinnon et al., 2010) and thus symbolise firmness and

courage. They usually fly in pairs and only have one partner during life (monogamous) (MacKinnon et al., 2010) and thus symbolise loyalty (STG089; BTG019). Their diets are some fruits (Phillipps & Phillipps, 2011), thus symbolising cleanliness and holiness (STG064). As a parenting pattern, the male birds care for their females and chicks, thus symbolising responsibility (MacKinnon et al., 2010; Pranoto et al., 2020).

The *tingang* motif contains a geometric transformation concept: a reflection on the y − axis. The point (x, y) is reflected on the y − axis, resulting in $(-x, y)$. The pairs of the origin and the image points by reflection on the y − axis in Figure 1 are $C(-1.4, 1.9) \rightarrow D(1.4, 1.9)$, and $E(-4.32, 0) \rightarrow F(4.32, \ 0)$. Although the figure is hand-painted, the right shapes are the repetitions of the left shapes and vice versa. Thus, the concept inherently exists in the Dayak Ngaju culture.

Figure 1

The Tingang Bird (left) (Davison & Fook, 2008), and the Tingang Motif (right) (Salilah, 1984)


The Dandang Tingang Motif

Dandang tingang (hornbill's rectrix) consists of three parts symbolising the human cycle, starting from the initial world (white), the secular world (black), and the heavenly world (white) (SDT029; BDT012). White symbolises divine power, and black symbolises human life that tends to rebel against the *Ranying Hatala Langit* (Figure 2). This motif advises humans to perform good deeds in the secular world in return for rewards in the afterlife. Life should not be too black because humans will return to the *Ranying Hatala Langit* in

the heavenly world (SDT029; BDT013). In addition, other reflected values can be analysed from the meaning of *dandang* as a caring act and *tingang* symbolising humans. Therefore, *dandang tingang* can be interpreted as humanising humans by their nature of living a polite and ethical life (*belom bahadat*) with other people, plants, and animals. Thus, *dandang tingang* symbolises the control of moral attitudes that reflect the universe (Ilon, 1987).

The *dandang tingang* motif contains a geometric transformation concept: the reflection on the $x-$axis. The point (x, y) is reflecting while the $x-$axis is resulting $(x, -y)$. The pairs of the origin and the image points by reflection on $x-$axis in Figure 2 is $C(0, 1.35) \rightarrow D(0, -1.35)$ and $E(-4, 1.35) \rightarrow F(-4, -1.35)$.

Figure 2

*The Dandang Tingang Motif and Its Values*
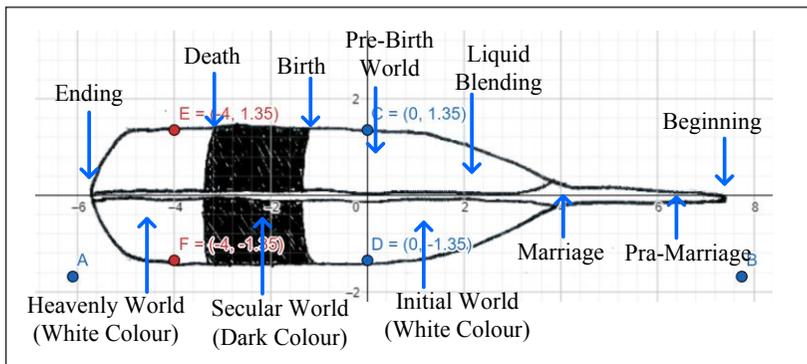
The Jata Motif

Jata (dragon) is the underworld symbol (SJT003; BJT017). Before the land existed, the *Ranying Hatala Langit* created *jata hai galang petak* (a great dragon that guards the underworld) to remind humans to do good deeds. Everyone will be asked about their good deeds before entering the underworld (SJT006; BJT018). The *jata* motif contains mathematical objects and a geometric transformation concept. The objects are two circles with a similar diameter (Figure 3). The diameters of the first and the second circles are $-1.48 - (-2) = 0.52$ and $-1.83 - (-2.35) = 0.52$, respectively. The transformation is the translation by $(10.46, -0.35)$ The pairs of the origin and the image points by the translation in Figure 3 are $C(-5, -2) \rightarrow E(5.46, -2.35)$, $D(-5, -1.48) \rightarrow F(5.46, -1.83)$.

Figure 3

The Jata Motif (Salilah, 1984)
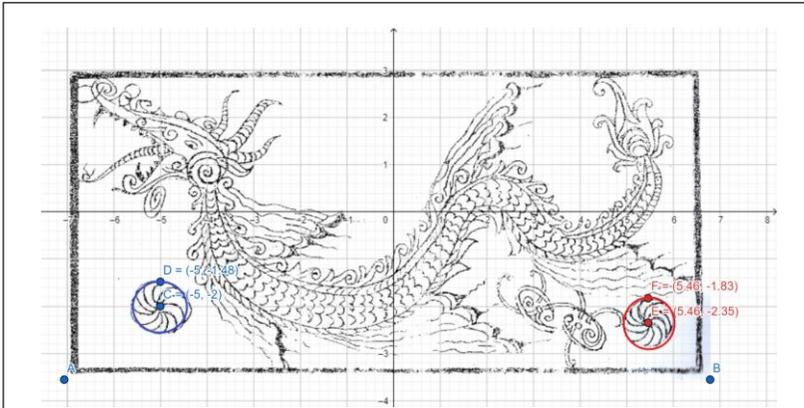
**The Batang Garing Motif**

Batang garing (the tree of life) is Dayak Ngaju's philosophy of life (SBG018; BBG003) (Ilon, 1987). It has at least seven parts. Every part reflects unique values (Salilah, 1984). The first part is *batang garing habatang rabayang* (a spear pointing upwards), symbolising humans' obligation to remember God (SBG019; SBG024; SBG075; BBG021). The second part is *babasung runjan* (a jug used as the basis), symbolising the event when *Ranying Hatala Langit* created water dripping for humans' life before everything in the universe. The jug symbolises wealth (SBG077; SBG078; BBG003; BBG023; BBG025). The third part is *babaner garantung* (a gong used as the root) (SBG021; BBG022; BBG025). As explained, the gong strengthens the foundation of life and reminds humans of the right path and the messages from the ancestors and the *Ranying Hatala Langit* (BBG003). The fourth part is *batunjang dohong, bahangkang bunu* (a dagger and a spear pointing upwards, used as the root). It has a value that humans should remember and obey the *Ranying Hatala Langit* to defend against bad things (SBG022; BBG028). *Batang garing* roots have various weapons symbolising heroism and bravery (Ilon, 1987). The fifth part is *bauhat rentai nyangkabilan bawakh* (intertwining large and small roots makes fibrous roots). Human life must be firmly rooted in the foundation (BBG028; BBG003). The sixth part is *mamua penyang* (bearing *penyang*). It symbolises intelligence,

faith, devotion, defence, and courage (SBG082; BBG028). *Penyang* is a talisman usually made of fangs (hunting trophy), wood, and small oil-filled bottles (SBG069; BBG028). The seventh part is *mandawen dandang tingang* (hornbill's rectrix as the leaf) (SBG018; BBG028), which symbolises control over moral attitudes that reflect the universe (Ilon, 1987). The motif's meaning is that humans should remember their creator, the *Ranying Hatala Langit*, and care for others and the environment (SBG038-040; BBG014) (Mirim & Sudiman, 2018; Santoso & Djamari, 2015; Siyok & Etika, 2014).

The *batang garing* motif contains a mathematical object and a geometric transformation concept. The object is a circle in the form of *a garantung* (gong), while the transformation is the reflection on the $y-$axis. The pairs of the origin and the image points by the reflection on the $y-$axis in Figure 4 are $C(-0.77, \ 0) \to D(0.77, \ 0)$, and $E(-0.86, \ -1.1) \to F(0.86, \ -1.1)$.

Figure 4

The Batang Garing Batik and Carving and the Batang Garing Motif

Batang Garing Batik   Batang Garing Motif
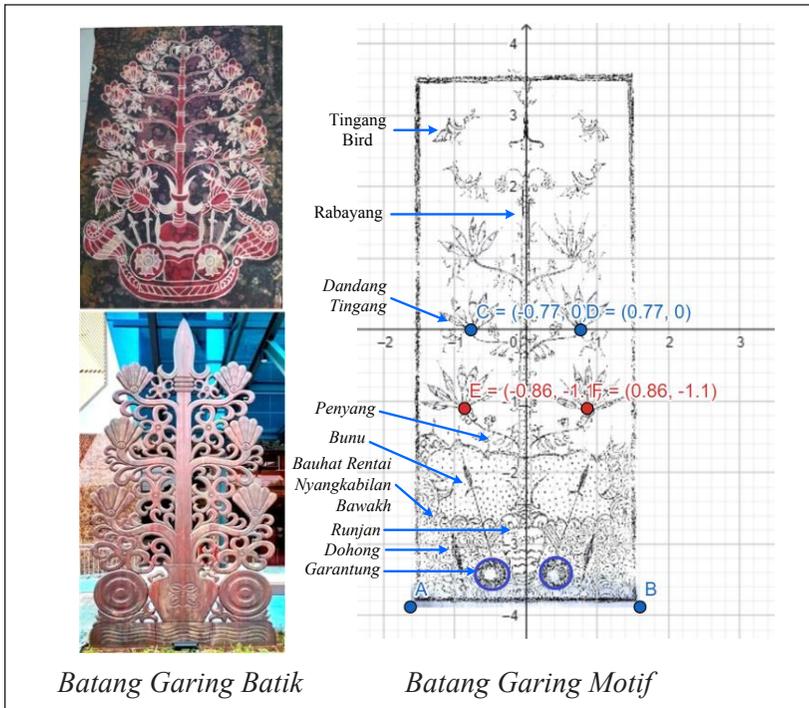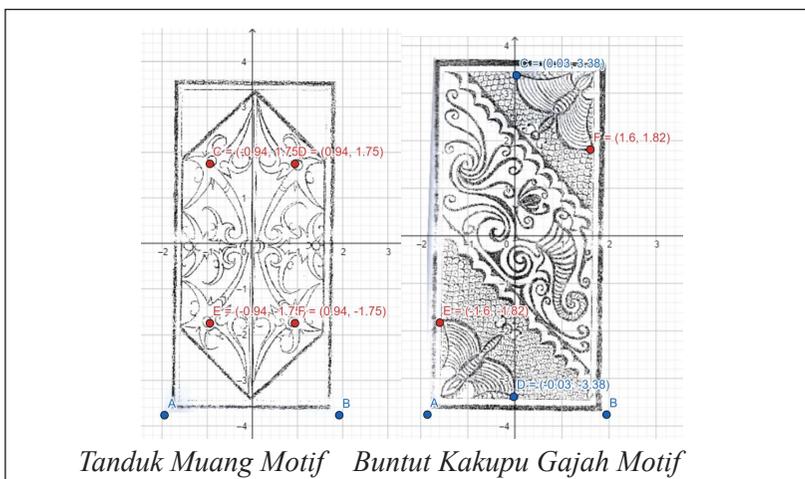
Source: Salilah (1984)

The Plants and Animals Motifs

Some Dayak Ngaju motifs are inspired by plants and animals (SMB002; BMB020). The motif means that the life of the Dayak Ngaju people depends on their environment, especially on plants and animals. Subject B stated, "Because our society used to be very engaged to the environment, animals, and many more. They live with the environment…" (BMB002). Subject S also made the same statement. He said, "In the old days, people did not destroy the forest because they lived around it. They knew plants were useful for their health, and the benefits were great. We must preserve the nature around us…." (SMB030). Thus, the Dayak Ngaju people must care for their environment (SMB030; BMB015; BMB020).

The examples of animals in the Dayak Ngaju motifs are *tanduk muang* (deer antlers), *haramaung* (tiger), *lamantek* (leech), *gajah* (elephant), *kakupu* (butterfly), or *sangkuwai* (owl). Some animal motifs are pictured in Figure 5. Each animal is beneficial for humans. For example, elephant ivory and leech are valuable as medicine for humans. In addition, some motifs have specific values, for example, the *tanduk muang* motif. "When a deer is born, it has no antlers. It will have its own experience. It will look for food on its own and with time, the antlers will grow. Therefore, we should be patient" (SHL007).

Figure 5

The Tanduk Muang Motif and the Buntut Kakupu Gajah Motif

*Tanduk Muang Motif   Buntut Kakupu Gajah Motif*

Source: (Salilah, 1984)

The *tanduk muang* motif contains objects and the geometric transformations concept. The mathematical object is a hexagon shape, and the geometric transformations are the reflections on the x- and y- axes. The pairs of the origin and the image points by reflection on the x −axis in Figure 5 is $C(-0.94, 1.75) \rightarrow E(-0.94, -1.75)$, and $D(0.94, 1.75) \rightarrow F(0.94, -1.75)$. Meanwhile, the pairs of the origin and the image points by reflection on the y − axis are $C(-0.94, 1.75) \rightarrow D(0.94, 1.75)$, and $E(-0.94, -1.75) \rightarrow F(0.94, -1.75)$.

The *buntut kakupu gajah* (butterfly and tail of elephant) motif contains a geometric transformations concept, namely rotation of 180^0 on $(0,0)$ point. A point (x,y) is rotated 180^0 on point $(0,0)$, and the image is $(-x, -y)$. The pairs of the origin and the image points by rotation 180^0 on $(0,0)$ in Figure 5 are $C(0.03, 3.38) \rightarrow D(-0.03, -3.38)$, and $E(-1.6, -1.82) \rightarrow F(1.6, 1.82)$.

Figure 6

The Taya Tree Motif and the Rambunan Tambun Motif

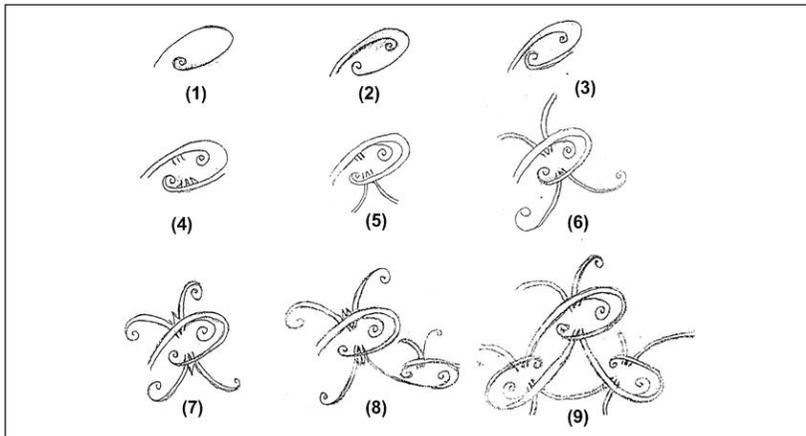| Taya Tree Motif | Rambunan Tambun Motif |
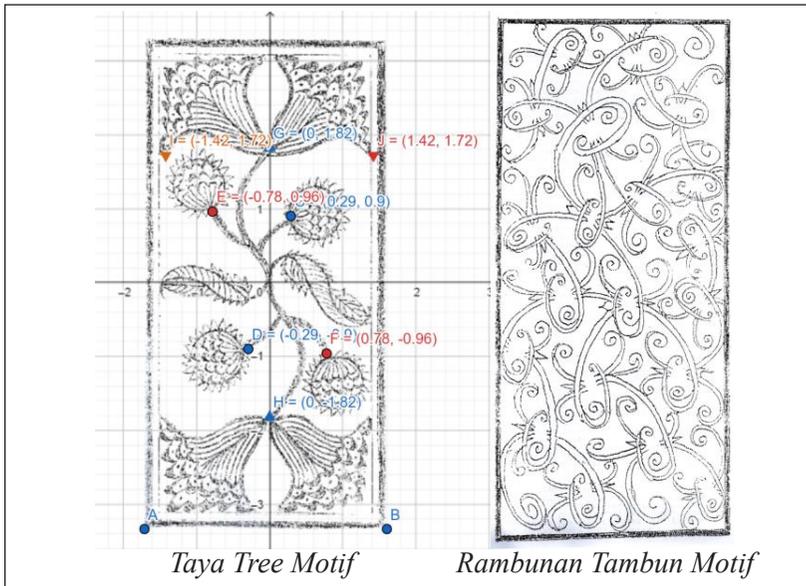
Source: (Salilah, 1984)

The examples of plants used as motifs are *bajakah maja*, *bajakah uyang*, *bajakah kalalawit*, *taya*, *kambang gahimis*, or some tree branches. The motifs of the *taya* tree and the *rambunan tambun* (dragon's nest) are shown in Figure 6. The *rambunan tambun* motif

is inspired by some tree branches (STL048; STL049; STL090). Each plant used as a motif is beneficial for humans. For example, *bajakah* can be used as medicine, and the leaves of the *taya* tree can be used as vegetables. In addition, some motifs have specific values, for example, the *rambunan tambun* motif. "This will not break up like a nested model. It also symbolises bravery in living life. If the Dayak people is *isen mulang*, they move on and look forward" (STL048; STL051).

The *taya* tree motif contains the concept of geometric transformations. The transformations are rotation 180^0 on point $(0,0)$, reflection on *the x −* axis, and reflection on the $y −$ axis. The pairs of the origins and the image points by rotation 180^0 on point $(0,0)$ in Figure 6 are $C(0.03, \ 3.38) \rightarrow D(-0.03, \ -3.38)$, and $E(-1.6, \ -1.82) \rightarrow F(\ 1.6, \ 1.82)$. The reflection on $x −$ axis is $G(0, 1.82) \rightarrow H(0, -1.82)$ and the reflection on $y −$ axis was $I(-1.42, 1.72) \rightarrow J(1.42, 1.72)$.

Figure 7

Sequence of Drawing the Rambunan Tambun Motif

Source: (Salilah, 1984)

The *rambunan tambun* motif has no geometric transformations concept. Although there are many shape repetitions, they are not congruent. The occurred repetitions can be studied in the motif's drawing sequence. The sequence starts from number 1 to 9, and the painter draws the shape repetitively (Figure 7). The painter draws the basics, expands the shape, and determines the direction of repetition as he wills (Salilah, 1984). Subject S stated, "The initial principle is here, this one, then continues here. Keep on connecting. Let me draw

the picture. It will not break, and it keeps connecting. Then it turns here and there. It keeps turning, and it fully develops here. As long as here and here is one, do not be afraid. This motif also means not to be afraid, go ahead …" (STL051). The advice "do not be afraid, go ahead" is known as *isen mulang* (persistence) among the Dayak Ngaju people.

DISCUSSION

The sacredness of the tingang bird is found in the Dayak Ngaju people in Central Kalimantan and the Dayak Kanayatan people in West Kalimantan, Indonesia. The bird, also called *Alo Rangokng*, symbolises several things. First, the bird is the first God's creature. Second, it is a medium between heaven and earth. Third, it is in charge of delivering the spirits of dead people to the final place. Fourth, it symbolises caring for nature and the human environment. Fifth, it symbolises human relations (Sahertian, 2021). Similarly, the Dayak people in East Kalimantan, Indonesia, interpret the bird as a symbol of goodness, good and wise leadership, loyal relationship (monogamy), and responsibility in protecting their children (Hanum & Dahlan, 2018; Marlina, 2019). Thus, despite the considerable distance between residences, there are similarities between the Dayak tribes across Kalimantan on the bird's sacredness. Kalimantan is the largest island in Indonesia. In general, the bird symbolises the heavenly world (holiness) and guides the Dayak people in Kalimantan to live, interact with each other, and care for the environment (Hidayat, 2021).

The animal motifs also exist in the Dayak tribes in Kalimantan. The Dayak Kenyah people in Samarinda, East Kalimantan, have the dragon motif. The dragon is an imaginary animal with the body of a snake that rules the underworld (Marlina, 2019). Similarly, the Dayak Iban people in Kapuas Hulu, West Kalimantan, use the motif in their traditional clothes (Yuyun, 2020), and so do the Dayak Jawatn people in Sekadau, West Kalimantan (Kusumayanti et al., 2019). In addition, the Dayak Kenyah people also use the motifs of other animals, namely *aso* (dog) and tiger (Marlina, 2019). Meanwhile, in the Dayak Ngaju tribe, animal motifs such as *tanduk muang*, *haramaung*, *lamantek*, elephants, *kakupu*, or *sangkuwai* are widely used to make *batik,* carving, and painting.

Moreover, Dayak tribes in Kalimantan also use plant motifs. Plants are commonly used as motifs because they are beneficial as food, medicine, and parts of environmental balance. The Dayak Kenyah

people in East Kalimantan use fern and tengkawang tree (*meranti*) motifs in their traditional clothes (Edi, 2021; Marlina, 2019). The motifs of ferns, bamboo shoots, leaves, and flowers in the Dayak Jawatn people in West Kalimantan are also used in their traditional clothing (Kusumayanti et al., 2019). The motifs of *karekot bajai* (ferns), *susuk rabung* (bamboo shoots), and taya trees also exist in the Dayak Ngaju tribe in Central Kalimantan (Kusni et al., 2011).

The motifs have some values related to philosophy, beliefs, or culture that exist in society. In Yogyakarta batik, the motifs of *baboon angrem, parang baron, parang klitik, sidomukti, semen bondhat, sidoluhur, soblog,* and *sidowirasat* have some unique values. The values are that parents should provide affection and be responsible for their children's growth and development; leaders should protect their followers; girls or women should have good knowledge and attitudes; humans should pray and depend on God for a prosperous and healthy life; humans should have physical and spiritual friendships; leaders must be trustworthy and provide welfare for their people; humans must pursue their dreams with persistence and patience; and parents must let their children get married and continue to provide advice and guidance in marriage (Prahmana & D'Ambrosio, 2020). In Surakarta batik, there are *wirasat sidamukti, sidaasih, sidamulya, parang pamor, parang canthel, nitik cakar, ceplok satriya, wibawa, truntum,* and *lurik yuyu sekandang motifs*. The values of the motifs are that humans should obey God, have affection, leadership, good attitude, and responsibilities in the family (Astriandini & Kristanto, 2021). Therefore, there are shared values between the Dayak Ngaju, the Yogyakarta, and the Surakarta motifs: humans must remember and depend on God, have good leadership, be persistent, loyal, responsible, and do good deeds for others (humanising humans). Therefore, ethnomathematics in Indonesia has values and perspectives on life that is useful for students' character building (Prahmana & Istiandaru, 2021).

Traditional clothes in different societies and cultures may have something common regarding ethnomathematics motifs. In Yogyakarta batik motifs, there are geometric transformations, namely reflection on y-axis, reflection on certain lines, translation, and rotation (Prahmana & D'Ambrosio, 2020). The motifs of traditional clothes of the Dayak Kenyah people in East Kalimantan (Marlina, 2019), the *Jember batik* (Amalia et al., 2021), and the *geblek renteng batik* in Kulonprogo, Indonesia (Fatkhurohman et al., 2021), have geometric transformations, namely translation, reflection, rotation, and dilation. In addition, the motifs of the Balinese *batik* (Irawan

et al., 2019) and the *Ngawi batik* (Fathikhin & Wijayanti, 2020) contain geometric transformations, namely translation, reflection, and rotation. The motifs of the *Banten batik* (Sianturi et al., 2022) and the Sidoluhur *batik* in Solo, Indonesia (Ishartono & Ningtyas, 2021) also contain geometric transformations, namely reflection and translation. Meanwhile, the motifs found in the Dayak Ngaju tribe, Central Kalimantan, have reflections on x – axis and y – axis, rotation 180^0 on point $(0, 0)$ and translation. Thus, geometric transformations are used in the motifs of cultural products across Indonesia.

Mathematical Lesson Based on Ethnomathematics in the Motifs

Ethnomathematics can be used in geometric transformation learning for junior high students. The intended use of ethnomathematics itself comes into problem-based or project-based learning. In problem-based learning, the teacher proposes the following ethnomathematics problem:

The Taya Tree Problem

The Dayak people have some motifs inspired by plants. One of them is the *taya* tree motif. The motif file can be seen and downloaded through this link: https://intip.in/5fMQ. Then, the file is to be displayed by using GeoGebra.

     i. Does the *taya* tree motif include geometric transformations? If so, determine the kind of transformations and prove them using GeoGebra. The process should follow the steps in the YouTube video at the link: https://youtu.be/pRhz0vhWO7I.
    ii. What is the value of the plant motifs? Let us find out by asking parents, family, and community leaders, searching books, or browsing the internet.
    iii. What are the benefits of the value for our success in everyday life?

In the following steps, students in groups construct the concepts and the formulas of geometric transformations (reflection, rotation, translation, and dilation) by answering some questions, completing some tasks, and solving problems involving ethnomathematics in student worksheets using GeoGebra. The solutions, then, are presented and discussed in groups to develop their understanding and positive attitude. In project-based learning, the teacher proposes the following ethnomathematics project:

The Batang Garing Project

The *tingang*, *jata*, *animal*, and plant motifs exist in the Dayak people outside of Central Kalimantan. However, a unique motif exists only in Central Kalimantan, namely the *batang garing*. It is the life philosophy of the Dayak Ngaju people in Central Kalimantan, meaning the tree of life. The motif file can be seen and downloaded at the link: https://intip.in/zt25. Then, the file is to be displayed by using GeoGebra.

i. Does the *batang garing* motif include geometric transformations? If so, determine the kind of transformations and prove them using GeoGebra.
ii. What is the value of the motif? Let us find out by asking parents, family, and community leaders, searching books, or browsing the internet.
iii. What are the benefits of the value for our success? Create an activity plan to practice the values in daily life activities.
iv. Implement the plan. Record it with a camera or a smartphone when your group is doing the steps. The record will also be the results of the implementation. Edit your video so the duration lasts for 10-15 minutes (the video should use background music, explanation text, an opening screen, and a closing screen).
v. Create a project report that includes a description of the plan, the implementation activities, and the results.
iv. Present the report and the video in groups in front of the class.

Finally, students in groups solve the project according to the syntax of project-based learning. The teacher provides learning resources such as student worksheets, learning videos, and modules. Students use them to learn geometric transformations independently. The project solutions are presented and discussed by the students in groups in the class to develop their understanding and positive attitude.

Using ethnomathematics in learning mathematics can help students develop problem-solving, higher-order thinking skills, and positive attitudes (Nur et al., 2020; Zaenuri et al., 2020). In addition, they can understand the practical applications of mathematics in everyday life (Jabar et al., 2022). The researchers used the GeoGebra application to explore ethnomathematics in the motifs, to encourage students to construct a meaningful understanding of geometric transformation

concepts, and to improve the quality of students' learning processes and outcomes (Asare & Atteh, 2022; Dahal et al., 2019; Mukamba & Makamure, 2020). Integrating ethnomathematics and computer/ smartphone applications is intended to bring advantages in mathematics learning and involve traditional culture in the modern Industrial Revolution era.

CONCLUSION

The motifs used by the Dayak people in Kalimantan, Indonesia, are famous for their beautiful shapes. The motifs comprise *tingang*, dragons, animals, or plants. The *tingang* symbolises glory and holiness, greatness, power, firmness, courage, loyalty, and responsibility. The dragon symbolises the underworld ruler who reminds humans to do good deeds in life. Using animals and plant motifs is intended to remind humans to care for their beneficial environment. Plants and animals are beneficial for food, medicine, and environmental balance. The Dayak Ngaju people in Central Kalimantan, Indonesia, have some distinctive motifs: *batang garing* (tree of life) and *dandang tingang* (hornbill's rectrix). *Batang garing* describes the command given by the *Ranying Hatala Langit* (God), the creator of the universe, to humans that they must remember Him and care for each other and the environment. The *dandang tingang* can be interpreted as humanising humans according to their natures by living ethically with fellow humans, plants, and animals (*belom bahadat*). Generally, the ethnomathematics aspect in the motifs of the Dayak people in Kalimantan comprises the geometric transformations concept, namely reflection, rotation, and translation. The motifs of *dandang tingang* and *tanduk muang* contain the $x-$axis reflection, and the motifs of *tingang*, *batang garing*, *tanduk muang*, and *taya* tree contain the $y-$ axis reflection. Meanwhile, the motifs of *buntut kakupu gajah* and *taya* tree contain the 180^0 rotation on point $(0,0)$. The motif of *jata* contains the translation. In addition, the Dayak Ngaju motifs contain mathematical objects such as circles in *batang garing* and *jata* motifs, and a six-sided shape in the *tanduk muang* motif.

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