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Mathematics Concepts in Making Kites as a Tool in Ethno-STEM based Learning

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Abstract

Kite is a traditional game with many mathematical concepts, making them applicable in ethno-STEM (science, technology, engineering, and mathematics) based learning. Therefore, this research explores the mathematical concepts inherent in kite flying related to ethnomathematics and STEM education. This research employs a qualitative exploratory approach. Data are collected through three methods: documentation, observation, and interviews. After collecting data, a descriptive analysis is conducted, including data reduction, presentation, and verification. Based on the data analysis, the mathematical concepts in kite-making include geometry, measurement, area and perimeter calculations, ratios and scales, patterns and symmetry, and arithmetic. Kite-making can be applied in ethno-STEM based mathematics learning as it aligns with the current curriculum and adheres to STEM learning principles. Therefore, kite-making can serve as a tool for mathematics education, making learning more meaningful, enjoyable, interactive, and contextual. This research exploration suggests that numerous mathematical concepts can be further examined in ethno-STEM based learning. Additionally, this research highlights the connection between mathematics and the socio-cultural context.

Keywords: Mathematics concepts, Kites, Ethno-STEM

INTRODUCTION

Emphasizing students' understanding requires an emphasis on their ability to make connections because when students can connect mathematical ideas, it leads to a more profound and enduring comprehension of mathematics. Mathematical connections refer to the relationships between different mathematical content as well as between the content and processes of mathematics (intradisciplinary connections), the connections of mathematics with other disciplines (interdisciplinary connections), and the connections of mathematics with the environment (cultural approach). Some experts consider it related to the ability to make connections to enhance student's understanding and the benefits of mathematics (Asfar et al., 2022; Baiduri et al., 2020; NIETO et al., 2021; Febriyanti et al., 2019; García-García & Dolores-Flores, 2021; Styasih et al., 2021). There are many theories regarding mathematical connections; this research focuses on the relationship between mathematics and culture, known as ethnomathematics.

The basic principle of ethnomathematics aims to explore and appreciate mathematical concepts in society's culture. In other words, ethnomathematics sees the relationship between the abstract world of mathematics and its application in everyday life (Rodríguez-Nieto et al., 2021). This idea emerged, referring to the fact that in mathematics, there is a dominance of measurement, calculation, and modeling processes, which are arranged in stages according to their structure in various practices in everyday life. The use of mathematics, for example, in commercial arithmetic, construction of buildings that potentially use geometric shapes, in the design, paintings, drawings, and the world of astrology. In other words, ethnomathematics allows for a connection between everyday experiences and institutional mathematics and can contribute to understanding mathematical concepts.

The context of ethnomathematics has not only analyzed the typology of internal and external relationships between measurement systems but can also be identified in design, calculation, explanation, location, play, approximation, and other universal activities.

Several studies related to ethnomathematics have been carried out (Risdiyanti & Indra Prahmana, 2020; Riyanti et al., 2022; Rizki et al., 2022; Rodríguez-Nieto et al., 2021; Suharta et al., 2021; Susanti, 2020). The culture that develops in society changes with changing times. Social, cultural, technological, and economic frameworks have generated new educational and economic advances. There has been a transformation in how information is captured and received and how knowledge is constructed. This has led many researchers to reflect on the new needs of schools and how to ensure that the education and training system adapts to societal demands. Hence, there is a need to break down barriers between disciplines, integrate them into the real world to tackle new realities, and promote relevant and authentic learning experiences such as STEM education.

STEM literacy is a learning need that supports active community participation, enables sustainable access to knowledge and learning, and develops critical and reflective thinking and values. STEM literacy does not mean achieving science, technology, engineering, and mathematics literacy in isolation. STEM is an interdisciplinary learning strategy rather than an abbreviation for four distinct subjects of study. Science, technology, engineering, and mathematics are demanding academic subjects that are employed in a practical setting to create links between the workplace, community, and multinational corporations. Some research based on STEM by (Astuti et al. 2021; Aykan & Yıldırım, 2022; Baharin et al., 2018; Beswick & Fraser, 2019; Lertdechapat & Faikhamta, 2021; Nugroho et al., 2022; Rachmawati et al., 2021; Rizki et al., 2022; Schmid et al., 2021). The combination of ethnomathematics with STEM education is known as ethno-STEM. Some of the results of research conducted to understand the influence of the use of mathematical concepts in ethno-STEM based learning include (Bravo et al., 2022; Mania & Alam, 2021; Sunzuma & Maharaj, 2022; Supiyati et al., 2019). Research on the implementation and effectiveness of ethno-stem approaches in various disciplines such as biology, physics, chemistry, and natural sciences.

Some existing literature has discussed developing critical and creative thinking skills and higher-order thinking. However, these studies still need to address the role of mathematical concepts in ethno-stem learning specifically, or there is still a need for research that studies the integration of mathematical concepts in ethno-stem learning. Mathematics plays a vital role in stem education, and its integration with ethno-stem approaches can enhance students' understanding of mathematical concepts in the context of local cultures and traditions. In particular, more research is needed to examine the relationship between ethno-STEM and learning outcomes. Understanding these relationships is critical to developing effective pedagogical strategies that leverage ethno-STEM principles to improve mathematics education. In addition, the literature highlights the need for integrated STEM education, the development of e-modules with an ethno-STEM approach, and the analysis of curricular materials for STEM integration based on engineering design developed by teachers. However, more studies are needed to investigate how mathematical concepts can be integrated into ethno-STEM based curricula to promote holistic learning experiences. Therefore, there is a need for research efforts that focus on investigating the impact of ethno-STEM approaches on the development of mathematical skills, conceptual understanding, and problem-solving abilities in diverse cultural contexts. This research can contribute to developing effective pedagogical strategies that utilize ethno-STEM principles to improve mathematics education.

One of the Indonesian cultures is kite games. A kite, also known as a *layang-layang* in Indonesia, is a thin sheet of material with a frame flown into the air and connected to the ground or a controller by a string or cord. Kites utilize the force of the wind to lift them into the air and are widely recognized worldwide as a recreational tool. Kite flying is one of the traditional games in Indonesia and is often played by children in open fields. It is not limited to just children; adults and parents also join in the kite-flying fun. Each region has its uniqueness or characteristics regarding kites. In Bengkulu, some well-known kites include bird-shaped kites, butterfly kites, centipede or dragon kites, ship kites, buzzing kites, nesting kites, and fish kites. Implementing kite flying in ethno-STEM based mathematics learning is a positive and highly beneficial endeavor for students. This is supported by several previous studies (Dewy et al., 2022; Muttaqiin et al., 2021; Rizki et al., 2022; Sumarni & Kadarwati, 2020)

Therefore, this research aims to explore the mathematical concepts involved in kite making and their potential for application in ethno-STEM based mathematics learning. The difference between this study and previous research is the deeper exploration of mathematical concepts within a culture and the analysis of their potential application in ethno-STEM based mathematics learning. The results of this research are expected to be applied in the mathematics learning process to enhance students' understanding and preserve one of Indonesia's local wisdom.

METHOD

It is advised to use a qualitative approach based on ethnography in ethnomathematics, where participant observation and semi-structured interviews—mostly via video recordings—are regarded as essential for gathering data. This study maps a rather deep object using an exploratory design and a qualitative research method. In this case, we explore the concept of mathematics in making a kite. This research develops an empirical phenomenon between three stages to analyze mathematical connections in daily practices.

Stage 1 - Subject Selection

Based on the results of the initial interviews, two kite makers were willing to participate in this research voluntarily.

Stage 2 - Data Collection

Data was collected through ethnography, involving participant observation and semi-structured interviews, focusing on the necessary information regarding the development of daily practices. Interviews were conducted at the participants' homes, beginning with initial questions and learning about their personal lives to gather data. Subsequently, follow-up questions were asked (for example, "What are the stages of kite making? What materials do you use?"), Moreover, finally, closing questions were posed concerning the marketing of each product.

Stage 3: Data Analysis

The functional, coordinated, and complementary use of conceptual tools by each theoretical approach served as the foundation for the development of data analysis. The three stages of the analytical process are shown in Figure 2. First, using ethnomathematics to investigate everyday behaviors, participants' mathematical conceptions are recognized without considering theoretical a priori elements or categorization. Second, every practice in daily life incorporates elements of the STEM approach—the link between science, technology, engineering, and mathematics. In the third stage, the exterior connections from an ethnomathematics perspective and the internal global and modern approach are used to characterize mathematical links. Furthermore, the results are presented, which refer to empirical

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phenomena related to daily life practices explored through ethnomathematics and STEM education to demonstrate mathematical relationships.

RESULTS AND DISCUSSION

1. Making Kite

In this first stage, two kite makers were followed, who created these artifacts for enjoyment or as a game for people of various ages. *Layang-layang* or kite, is a thin, skeletal sheet of material blown into the air and connected by rope or thread to land or controllers. Kites utilize the power of wind gusts as a means of lifting. It is widely known worldwide as a gaming tool. Kite is one of the traditional games from Indonesia. Children often play with kites in the field. Not only children but adults and older people also play with kites. Each region has its uniqueness or characteristics about kites. Some kites known in Bengkulu are bird-shaped, butterflies, centipedes or centipedes, ships, types of buzzing kites, lambing kites, and fish. The figure if Bengkulu kite can be seen in Figure 1.

Figure 1. Bengkulu Kite

From an ethnomathematical perspective, it is noted that both participants craft kites through five steps using wooden sticks (typically bamboo), which are measured using non-conventional measurement units, namely, the span of the hand and 'jengkal' to determine their size (first step), and typically, three rods or five ribs of a bow kite (second step). Furthermore, the bamboo sticks (rods) are tied with a cord, rope, nylon, or string, considering the Centre of the rods that alludes to the symmetry of the kite (third moment). The kite makers then use a rope that serves as a measurement pattern to confirm the kite's structure (fourth instant). Paper or plastic is used to line the kite's construction, or skeleton, with the quantity of sheets varying according to the kite's size (fifth moment).

In this context, we will delve into the kite's structure, its elaboration materials, and its role in teaching and learning mathematics and other branches of science. From the perspective of STEM education, technological knowledge is employed in the construction of kites in addition to mathematical understanding. Depending on the ingenuity of the kite maker, Figure 3 shows that geometric forms like scalene triangles, isosceles triangles, rhombuses, hexagons, stars with different-numbered points, squares, and rectangles are taken into consideration for the kite design. For instance, P1 just created the comet's structure, but P3 created fan and star forms composed of hexagons and triangles, and the symmetrical line is visible in the kite's center.

The kite has complementary additional angles and opposite angles by the vertices. As previously mentioned, technology also becomes involved in the process of producing kites, which is a human endeavor to address demands or find solutions to issues at hand. Artifacts are typically made for this purpose; items like computers, robots, televisions, clothing, furniture, pots, and phones are among the items used. That is, technology encompasses all of humankind's creations informed by science. As previously mentioned, art is also present because the kite maker's ingenuity has a major role in the final product's appearance. These objects grab the interest of adults and kids of all ages, making the kite an invaluable and inspiring tool for, in a globalized educational setting, bridging mathematics with one's own culture and the real world.

Given the objectives, which specify that "students can measure the angles of the triangles in the kite and see that their corresponding angles are congruent," the mathematics instructor in a geometry class should design exercises aimed at building various kinds of kites. By measuring the triangles' side lengths, they are able to determine that the differences are not constant but rather are connected by a constant scale factor. Students can therefore start to formulate a more formal definition of similarity in terms of relationships between sides and angles with the help of the teacher. However, since "students will learn about motions and forces, transfer of energy, abilities of technological design, energy in the earth system, science as a human endeavor, and historical perspectives as they create their kites," we find the development of kites and their introduction into science classrooms, including mathematics classrooms, to be relevant." (NASA, 2016). Developing kids' knowledge of mathematical and geometric concepts and phrases so they may use them to create kites is one of NASA's key objectives. For instance, kids gain from flying kites because it helps them understand aerodynamic forces.

2. Making of Box Kites

The subject follows six months to make box kites (See Figure 2) and analyze from the ethnomathematics tics perspective. In order to obtain a rod, he first measures the bamboo with the meter or "by eye." He then uses the first measurement as a blueprint to obtain other rods, until six are obtained. The subject used the term "by eye" to describe a measurement of about 80 cm, pointing out that since it is one meter from the feet to the height of the navel, it is equivalent to the measurement from below the navel. In the second instance, he created the squares where the rods are kept using the "bamboo stick" measurement pattern, with four long rods making a parallelepiped. Third, the two long rods that are left cross to create a square with four 90° angles. The rods that created the parallelepiped are connected together in the middle by a string (fourth moment). To ensure uniformity in the box structure, the subject links the ends of the square and the parallelepiped at the fifth moment. It is lined with paper at the sixth moment, so the subject may make out the squares, rectangles, and right triangles. Geometric concepts from STEM education can be identified, including the segment, rectangle, triangle, trapezium, square, and parallelepiped. These concepts can be used to problematize concepts in the classroom, such as the kite, and include the areas of plane figures, core areas, volume of three-dimensional figures, measurement of segments, types of angles, symmetries, and parallel and perpendicular lines. In the following interview snippet, subject (S) demonstrates certain mathematical ideas:

S (Subject)	*Since this is a right angle from here to here, the measurement should be made at a ninety-degree angle. Look at this white paper; it's a triangle. Pointing with a finger, it has three sides: one, two, and three. It's a blue triangle with three sides that is also another triangle when viewed as a whole.*
R (Researcher)	*Here (pointing to the right-angle point) What happened?*
S (Subject)	*Here it should be straight, right angles, where two bars meet, it should be straight, put a square here and it should be straight.*
R (Researcher)	*Right angle? What does it mean?*
S (Subject)	*So that this skeleton doesn't shift up and down then he has to be straight*
R (Researcher)	*if you look at the right triangle, what is the function of your explanation?*
S (Subject)	*That is, the shape, has a shape like that plane..., for example this is a triangle, until here it is square, the first to be assembled is a rectangle, which is four bars (...), this here forms a right angle, I put a square here*

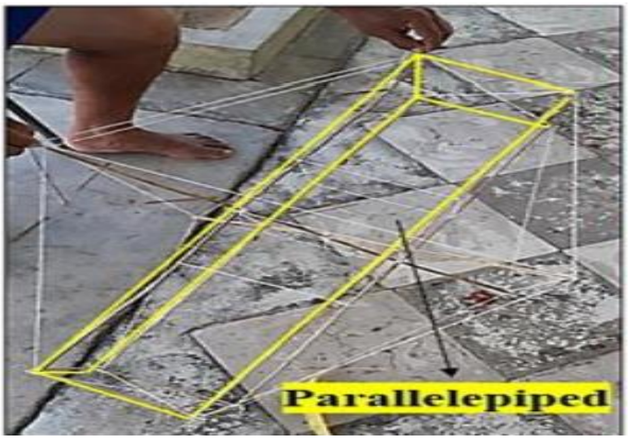

Figure 2. Box of Kite

Comparable to the kite, the box kite's design demonstrated both technological know-how and artistic inputs. This artifact is well ingrained in Bengkulu culture as a component of amusement, and a clear link with the cultural milieu is made. Thus, making use of this circumstance in the classroom provides this globalizing technique whereby information of various kinds is related to mathematical understanding with reality in addition to being integrated.

It should be noted that, in contrast to other theoretical networks that have focused on argumentative grammar (Tabach et al., 2020), on exploring the idea of the mathematical object in greater detail (Font Moll et al., 2016), or on describing the idea of mathematical connection as the tip of an iceberg consisting of a conglomerate of practices, processes, objects, and semiotic functions that relate them (Rodríguez-Nieto et al., 2022). From this vantage point, our research has aimed to expand on earlier attempts to formulate some of these theories, such the work of Rosa and Orey (2021), which used several instances to approach an ethnomathematical perspective of the STEM method. In our instance, the relationships that arise in different everyday practices from the articulation between STEAM education, ethnomathematics, and the globalized approach have been examined in order to enhance the current understanding of mathematics' function and application based on a joint examination of the role of culture, interdisciplinary research, and reality understanding.

The results showed that artisans have unconsciously used various mathematical concepts in making kites. For example, in carrying out the process of determining symmetry so that the kite's shape becomes the same left and right, this activity uses the concept of symmetry and the concept of dividing points. Likewise, determining the kite's balance to fly is known as 'equilibrium,' which contains the concept of weight. This shows that making kites can be used to learn mathematics, where students can discover these mathematical concepts for themselves.

The implementation of ethnomathematics has also been shown to positively influence students' mathematical attitudes, conceptual understanding, and motivation, leading to improved mathematical representation abilities and cognitive styles (Kowiyah et al., 2019; Sinambela et al., 2022; Virgana, 2019). In addition, the use of ethnomathematics in mathematics education has been found to contribute to the improvement of school mathematics and the development of mathematics learning (Hendriana & Buyung, 2020; Bravo et al., 2023; Nur et al., 2020).

Ethnomathematics provides a platform for students to explore mathematical concepts in cultural activities; this is in line with several other studies that focus on ethnomathematics to make mathematics more relevant and meaningful for students (Peni, 2019; Fatoni et al., 2023; Wahyuni et al., 2023; Wahyuni et al., 2022). By incorporating ethnomathematics into mathematics learning videos and realistic mathematics education, students can be empowered in their learning activities and develop a deeper awareness of cultural relevance to their education (Yandani & Agustika, 2022). In addition, ethnomathematics-based problem-solving approaches have improved students' numeracy literacy skills and understanding of mathematical concepts (Iswara et al., 2022; Yuliana et al., 2022).

This illustrates that ethnomathematics is essential in connecting mathematical concepts with students' cultural backgrounds and everyday experiences. Ethnomathematics involves the study of mathematical concepts in local cultures, and their implementation in mathematics education has shown a positive impact on students' learning experience and mathematical understanding (Ergene et al., 2020; Hendriana & Buyung, 2020; Ida, 2023; Iswara et al., 2022; Bravo et al., 2023; Pathuddin et al., 2021; Prahmana et al., 2023; Virgana, 2019; Yuliana et al., 2022).

Integrating ethnomathematics into learning activities or in the curriculum can help students understand the relationship between culture and mathematics, leading to improved mathematical literacy and problem-solving skills (Aminah & Syamsuri, 2022; Sinambela et al., 2022; Fatoni et al., 2023; Yandani & Agustika, 2022).

In conclusion, ethnomathematics offers an excellent approach to improving students' understanding of mathematics by bridging mathematical concepts with cultural experience. The integration of ethnomathematics in the curriculum can help teachers create meaningful and engaging learning experiences and empower students to develop a deeper understanding of mathematical concepts and their cultural relevance.

CONCLUSION

The primary mathematics concepts that can be explored in the traditional kite local wisdom culture are geometry, measurement, area and perimeter calculations, ratios and scales, patterns and symmetry, and arithmetic. Kite-making can be applied in ethno-STEM based mathematics learning as it aligns with the current curriculum and adheres to STEM learning principles. Therefore, kite-making can serve as a tool for mathematics education, making learning more meaningful, enjoyable, interactive, and contextual. This research exploration suggests that numerous mathematical concepts can be further examined in ethno-STEM based learning. Additionally, this research highlights the connection between mathematics and the socio-cultural context.

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