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Ethnomathematics: Geometry and architecture of the *tharu's* traditional houses at Chakhoura museum

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Abstract
Tharu is one of the indigenous research communities having their distinctive culture and practices. They have their own mathematical ideas and practice concepts to perform everyday activities. The study of mathematical ideas and knowledge practice in a particular group of people which is generally ignored by the formal curriculum is known as ethnomathematics. This study is intended to uncover the mathematical concepts embedded in the construction of traditional *Tharu* houses at the Chakhoura Museum. For this purpose, this study has carried out the observation and documentation analysis method for data collection. The resketching of the image of the traditional houses obtained in the field is carried out to facilitate the art, structures, and designs of construction systems of the traditional house. Most of the local knowledge developed by *Tharu* communities regarding the architecture of traditional houses is usually based on intuition, estimation, observation, and practice handed down from generation to generation closely related to their local culture. Therefore, emic ethnomodeling is used to explore the mathematical ideas embedded in the architecture of traditional houses.
The result showed that the architecture of *Tharu's* traditional houses demonstrates sophisticated geometrical objects, namely, angles, lines, parallel lines, triangles, rectangles, squares, pentagons, circles, cylinders, and so on. The result also showed that the geometrical ideas contained in the *Tharu's* traditional houses include a prism. Thus, the result of this study exhibits the diversity and sophistication of mathematical practice in traditional houses made by *Tharu* communities that have a strong foundation in popular scientific understanding, such as geometric shapes in arts, crafts, architecture, and design.

Keywords: Ethnomathematics, architecture, culture, geometry, indigenous knowledge

Introduction
Nepal is a multilingual, multicultural, and multi-religious nation. Geographically, linguistically, caste-wise, ethnically, religiously, and culturally, it is diverse. There are 59 indigenous nationalities, each with a unique culture. One of them is *Tharu*. One of the main ethnic groups in Nepal is the *Tharu*, who make up 6.2 percent of the overall population of Nepal (Census, 2021). They live in the Terai region, which stretches from Kanchanpur in the west to Jhapa in the east. They primarily live in twenty-two Tarai districts in the interior Terai region. Even though in Nepal the word "*Tharu*" refers to a single community, there are actually various subgroups that fall under it due to cultural and linguistic variety. Additionally, they go by the regional names Deukhuriya and Dangaura in the middle Tarai, Rana in the far western Tarai, Kochila in the eastern Tarai, and Chitwaniya and Desauriya in the center of the region. Each subgroup consists of a variety of ethnic characteristics that are combined with everyday practices of ethnomathematical concepts. Therefore, this study will examine what, how, and what role ethnomathematical concepts have in the *Tharu* community of Nepal.
The village of Chakhora is situated in Dangisharan-3, Dang, Nepal. There is a well-known museum dedicated to the *Tharu* people, where you may see examples of their traditional homes, way of life, and daily activities. The inhabitants of the Dang district and all of Nepal see this location as one of the top tourist destinations.
However, due to the conflict between maintaining inherited cultural traditions and keeping up with globalization, certain places are negatively impacted by it. In order to preserve their presence in society, today's youth generation may have to deal with the challenges of integrating their inherited culture with technology. It seems that the challenges faced by each new generation in *Tharu* culture are similar. The *Tharu*s' civilization is conscious that cultural diversity and customs are just as important to attracting as natural beauty. Therefore, it is crucial that culture and noble principles continue to exist. The experts believe that formal

education is vital in helping to actualize these commitments. Because such education makes it possible to integrate honorable cultural values into the curriculum. Mathematics is one of the subjects that enables the integration of culture and its high ideas.

In particular, the existence of ethnomathematics serves as the answer to the problem of cultural preservation, technological advancement, and artistic mastery. Ethnomathematics is a way of expressing the relationship between culture and mathematics (D'Ambrosio's, 2006).

The investigation of *Tharu*'s ethnomathematics and its connections to mathematical ideas taught in schools should therefore come next. Because ethnomathematics is a relatively new concept or program in the educational field, there aren't many publications about *Tharu's* culture that cover the subject. This is congruent with Powell, who asserts that anthropometrics is a relatively new field of study that adopts a logical structure (Powell & Frankenstein, 1997) [7].

Mathematics and cultural growth are integral to human civilization. Therefore, the growth of mathematical activity cannot be isolated from culture (Muhtadi, 2017) [4]. Through the ethnomathematics program, mathematics and science also contribute to cultural development, and cultural activities can be used to teach the concepts (Umbra, U., Wahyudin, W., & Prabawanto, S., 2021) [13]. Mathematical concepts are created by cultural individuals who can resolve problems in their environment and build them to use as a thinking tool to simplify challenging circumstances (Budiharto, 2019) [2]. This circumstance enables the blending of mathematical ideas with local cultural norms. Students may find it simpler to combine the two results in mathematical contexts and applications. Students may find it simpler to combine the two results in mathematical applications that are realistic and relevant. The notion of mathematics will be more meaningful when it is taught by considering the culture in the cultural community, which has been introduced to kids since preschool age (Budiarto, 2019) [2].

Fundamentally, mathematics is a symbolic technology that develops from culturally specific knowledge or environmental practices. Accordingly, a person's mathematical abilities are influenced by their cultural background due to what they perceive and experience. Individual conduct will be influenced by culture, which also plays a significant part in the growth of personal understanding, including learning that has been genuinely incorporated into communal life. Architecture is one example of a cultural output that is visible. Humans attempt to produce numerous forms in architectural works, incorporating them into various symbols and building concepts. (Bishop, 1994) [1].

Ethnomathematics recognizes the existence of various applications of mathematics in people's lives or activities and serves as a bridge between mathematics and culture. When conducting study in the subject of cultural anthropology, ethnomathematics is a method that is more commonly utilized. It investigates the mathematical culture of a community group and considers its history and philosophy (Sugiyono, 2012) [13].

One of the existing cultural artifacts is a *Tharu's* traditional house. Ethnomathematics are widely used in *Tharu's* culture and are continuing to develop without the *Tharu's* people even being aware of it. This conventional home also has unique features in the way it is constructed. Mathematical ideas can be assimilated into the *Tharu's* home's architecture. The components consist of a systematic arrangement of geometric shapes with mathematical underpinnings and elements of ethnomathematics. Each culture has its own mathematics because each group of people has to develop its own system of Maths.

There are several *Tharu's* traditional houses are there in the Chakhoura Museum, each of which represents a unique type of *Tharu's* focused throughout east to west Nepal. The main interesting concept as the result of exploration may be found in the concept of different types of mathematics is applied by the architecture of *Tharu's* traditional house.

The main objective of this study was to explore the ethnomathematical ideas that were integrated in the activities that occurred in traditional houses in the *Tharu* community in Nepal, with the aim of addressing the following research issues.

- What mathematical concepts are incorporated into the traditional *Tharu's* houses?
- How does the *Tharu's* culture develop mathematical knowledge for the construction of traditional their houses?

Method

The goal of the study was to show the pedagogical application of ethnomathematics to teaching and learning. The theoretical framework on the teaching and learning of mathematical concepts based on the ethnomathematics handbook presented by Forbes, (2018) [3] serves as the inspiration for the study. Several ethnomathematics philosophers have sought and indicated the aim of producing mathematics lessons and curriculum implementation ethnomathematics pedagogically based teaching (Peni & Baba, 2019; Putra, 2018; Rosa & Orey, 2019) [6, 10, 11]. The purpose of the study was to determine whether an exploratory mixed technique was necessary to determine how ethnomathematical movements affected the teaching and learning process. Selected mathematical ideas that conform to *Tharu's* ethnomathematics as resourceful teaching of the constructions were used as examples of ethnomathematics education. We investigated the mathematical ideas in *Tharu's* culture and showed how they affected formal mathematics instruction and learning.

In order to achieve our goals, a hybrid methodology (qualitative and quantitative methodologies) was used in this study. Before doing a group analysis and interpretation with regard to this type, the researchers collected qualitative and quantitative data. During the qualitative phase of their investigation, the researchers spoke with a specialist in traditional houses and traditional house architects. After that, the information gleaned from the interviews was compared to the hypotheses advanced in several related literature. The researchers also conducted the same activity with chosen *Tharu* people who were knowledgeable about the history of such traditional constructions.

Result and Discussion

Tharu's ethnomathematics is a collection of fundamentally sound artifacts that demonstrate an understanding of mathematical ideas at the most fundamental level. *Tharus* used to reside in *Tharu's* houses, and he redesigned them using his mathematical knowledge, know-how, and skills. Research has been conducted to examine additional connections between ethnomathematics and already-established cultural (Pradhan, 2017; Pramudita & Rosnawati, 2019; Owusu-Darko, Sabtiwu, Doe, Owusu-Mintah, & Ofosu, 2023) [8, 9, 5].

The elderly man builds traditional *Tharu's* houses. The building materials for the house are stones, mud, wood, and

Khar. Because Khar is thatched, the roofs are slanted. The primary functions of a house are as a place to live and a place to store things; houses are constructed in accordance with human needs. The management of windows, doors, and ventilations. For air flow, there are fixed small holes. People have a tradition of painting various bright pictures on walls. Stone and wood carvings are used to create decorations.

Fig 1: The *Deukhuriya* house which is currently being constructed (Source: field survey)

Fig 2: The structure that was constructed originally a house of the *deukhuriya* design (Source: field survey)

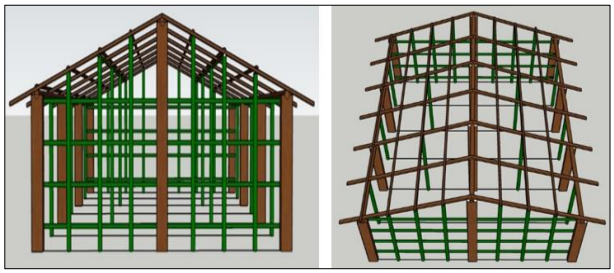
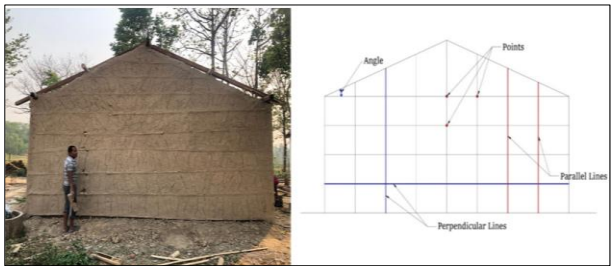


Fig 3: Resketching of *Tharu's* traditional house



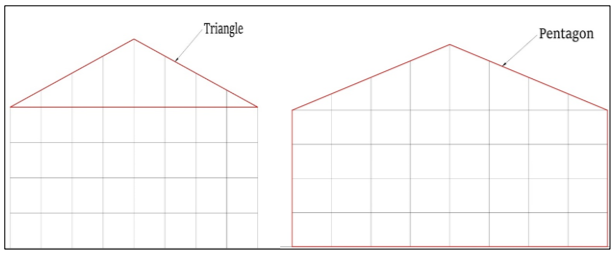


Fig 4: Concept of points, angles, perpendicular lines, parallel lines Polygon from *Tharu's* traditional house

Without having any mathematical schooling, the *Tharu* people in Figure 4 are still using terms like points, angles, lines, parallel lines, perpendicular lines, and polygons while constructing traditional houses

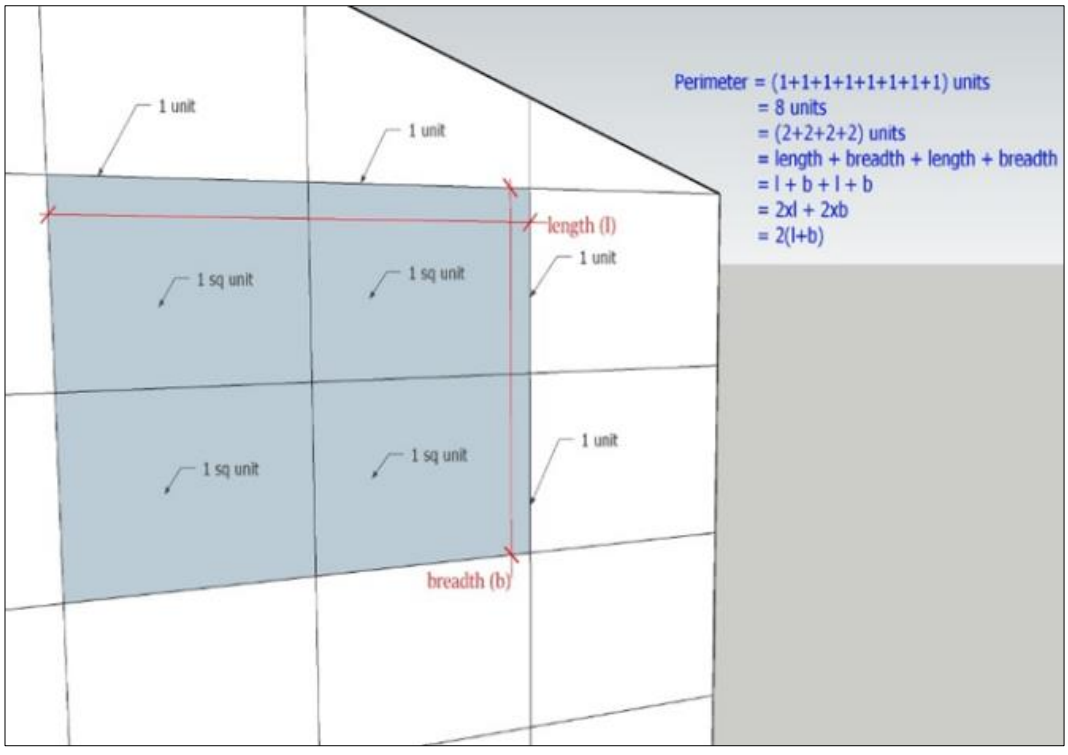


Fig 5: Concept of Perimeter from *Tharu's* traditional house

Figure 5 demonstrates the perimeter concepts from the construction of the traditional *Tharu's* house and instructs the new student who wishes to learn about the perimeter concept in learning activities in academic course.

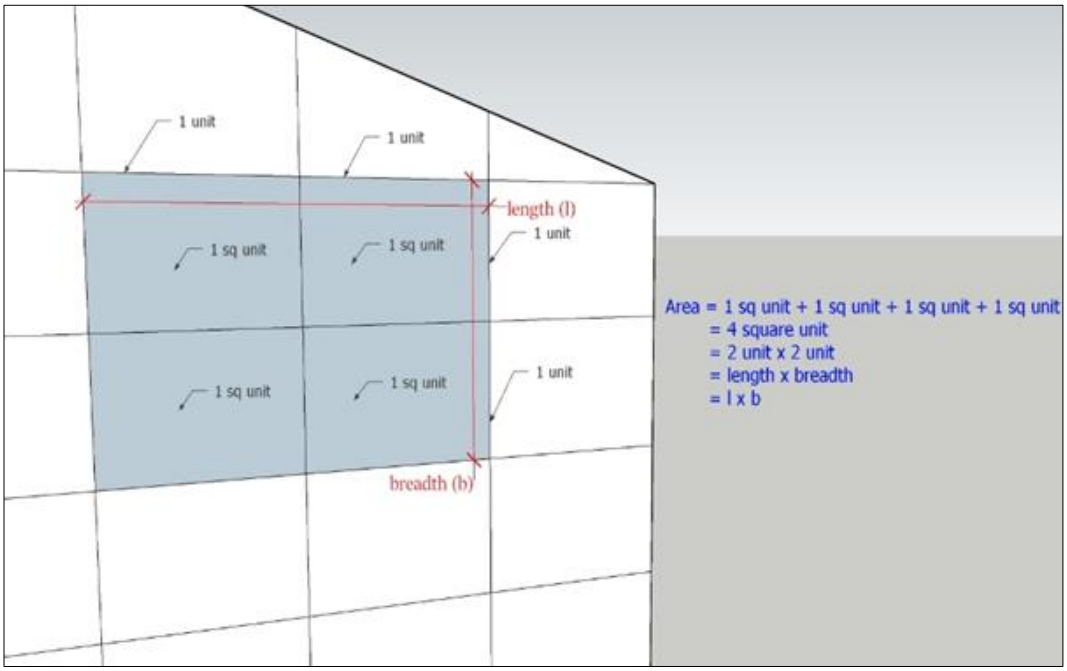


Fig 6: Concept of area from *Tharu's* traditional house

Figure 6 demonstrates the area concepts from the construction of the traditional *Tharu's* house and instructs the new student who wishes to learn about the area concept in learning activities in academic course.

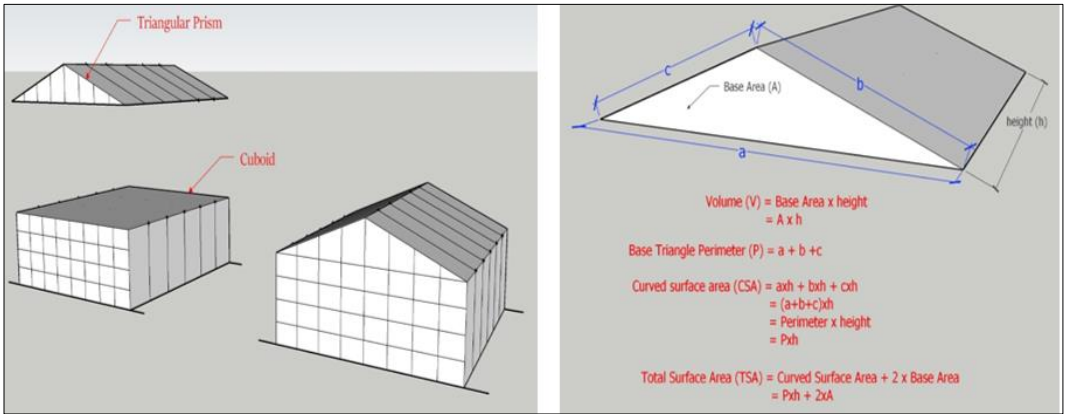


Fig 7: Concept of the prism from *Tharu's* traditional house.

The *Tharu* people built traditional homes without having any mathematical understanding of prisms, but they unintentionally created prisms. We may provide the principles of prism from these houses by resketching their house.

The three-dimensional geometric structure known as a prism is made up of two bases connected by a number of parallelogram or rectangular faces that are both congruent and parallel polygons. The bases' respective sides are connected by these vertical lateral faces. The parallel bases are the same size and shape. The distance between the bases of a parallelogram equals the height of the prism. The four elements of a prism are its base area, curve surface area, total surface area, and volume.

Figure 7 illustrates how curved surface area, total surface area, and volume ideas are introduced in formal education.

Curved surface area (CSA) = ah +bh +ch = (a + b + c) h

Total surface area (TSA) = 2 Base area + CSA

Volume = Base area × height = A h

So, to touch basic concepts on teaching technique, various mathematical concepts are used from above resketching *Tharu's* traditional houses figures such as points, lines, perpendicular lines, parallel lines, triangle, quadrilateral, pentagon, perimeter, area, volume, and prism.

Conclusion and Recommendation

Numerous mathematical ideas have cultural contexts. *Tharu's* ethnomathematics appear to contain geometric and mensuration content. Two examples of mathematical subjects that can be taught and learned in *Tharu's* home are mensuration and geometry. The formal and informal mathematical concepts incorporated in the school-based curriculum are more clearly interconnected, as seen through conversations and analyses of *Tharu's* re-sketching. There are many creative teaching situations where the educational tactics gained from this core application of ethnomathematics might be applied. Due to the *Tharu* households' usage of

ethnomathematics, children from the communities may follow the lesson plans and enhance their acquisition of mathematical skills. The findings indicated that the *Tharu* people's traditional houses exhibit complex geometrical items in their architecture, including angles, lines, parallel lines, triangles, rectangles, squares, pentagons, circles, cylinders, and others. The outcome also demonstrated that a triangular prism is among the geometrical concepts found in the *Tharu* people's traditional homes. As a result, the study's findings show the variety and sophistication of mathematical practice in the traditional homes built by *Tharu* people, including the use of geometric shapes in creations, crafts, construction, and design.

Informal application of mathematics is typically found in *Tharu's* houses. Traditional *Tharu's* houses were created based on ideal ethnomath and ethnotech. Identification of the connection to the formal approach to teaching mathematics is severely constrained by the informal stance of knowledge transmission of these ethnomathematical ideas. To begin with, it is necessary to think about formalizing informal ethnomathematics through proper ethnomathematical pedagogies in order to adjust in some way to the formal curriculum implementation processes. If we are willing to acknowledge culture's incorporation into the teaching and learning processes, culture has much to offer math educators.

We urge further research into the practical value of the ethnomathematics approach in educating students about other mathematical ideas in various settings where there is cultural variety. It is advised that math teachers adopt the ethnomathematics technique and incorporate it into the process of implementing the curriculum to determine how it affects math instruction.

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