Indonesian Journal of Ethnomathematics
Volume 2, No. 1, 2023, pp. 1-16
ISSN 2775-8001

Mathematical Knowledge on Changu Narayan Temples' Arts and Architectures: Ethnomathematics Perspective

Kharika Devi Parajuli

Mathematics Education, Tribhuvan University, Kathmandu, Nepal
E-mail: kharikaparajuli@gmail.com

Abstract

This paper thoroughly explores the intricate nexus between mathematical knowledge and the artistic and architectural elements of Nepal's Changu Narayan temple, employing ethnography as its methodological framework. Through meticulous observation, documentation, and analysis, the study unveils a rich repository of mathematical concepts intricately woven into the temple's structural design, encompassing geometric principles and mensuration spanning two-dimensional and three-dimensional shapes. From similarities in trapeziums and congruent rhombuses to the incorporation of circles, semicircles, and diverse triangular configurations alongside complex solid shapes like right circular cones, rectangular-based pyramids, and square-based cuboids, the temple serves as a vivid testament to the enduring significance of ethnomathematics within Nepalese culture, particularly in Hindu religious practices. This symbiotic relationship between mathematics and cultural traditions underscores the profound relevance of ethnomathematics as a pedagogical tool, fostering mathematical comprehension and appreciation among students. Thus, the findings advocate for integrating ethnomathematics into school curricula, harnessing cultural artifacts such as the Changu Narayan temple as potent resources for advancing mathematical education.

Keywords: 2D and 3D Shapes, Ethnomathematics, Geometry, Mensuration, Temples' Art and Architecture

How to Cite: Parajuli, K. D. (2023). Mathematical Knowledge on Changu Narayan Temples' Arts and Architectures: Ethnomathematics Perspective. *Indonesian Journal of Ethnomathematics, 2*(1), 1-16. http://doi.org/10.48135/ije.v2i1.1-16

Introduction

Nepal is culturally rich in arts and architecture. Kathmandu, the capital city, has many Hindu temples with shikhara ('mountain top') styles. These temples are rising towers, domes (Stupa), and tiered temples (ranging from single to multi-tiered). The third one is rectangular, with levels ranging from one to three (Shilpakar et al., 2021). The famous Changu Narayan Temple uses art, architecture, and carving design, which can be observed through a mathematical lens.

This temple was built during the Lichchavi Dynasty. This temple is located in the Bhaktapur district of Nepal. Changu Narayan's art and architecture can be seen in 2D and 3D geometric shapes and the mensuration of school mathematics. However, Nepalese teachers have yet to use these shapes to teach mathematics in their classrooms. The articles of D' Ambrosio (1990), Johnson et al. (2022), and Rosa and Orey (2011) have given clues to examine the cultural aspect of mathematics. The work of Fitrianawati et al. (2020), Mania and Alam (2021), and Narulital et al. (2019) reminds the researcher that Nepali religious shrines are the best sources of school mathematics.

The articles by Apriandi and Ayuningtyas (2022) and Muhtadi et al. (2017) on ethnomathematics areas led the researcher to search, read, and connect the contents of school mathematics on geometry for interaction. Turan and Matteson (2021) and Orey and Rosa (2020) have used ethnomathematics to promote a student-centered approach to teaching. However, D'Ambrosio (1989), Fitrianavati et al. (2020), Pathuddin and Nawawi (2021), and Orey and Rosa (2010) have suggested that entertainment and mathematics refer to learning together with cultural activities through an ethnomathematics perspective.

Marsigit (2014) has brought another perspective. The author maintains that ethnomathematics acknowledges the culture and helps learn mathematics entertainingly. Their research on the temples of the Sultan Palace of Yogyakarta is a good example to work in this direction. Apriandi and Ayuningtyas (2022) reported that Tamansiswa's Special Region of Yogyakarta, the Shiva Temple, can be used as a tool to teach mathematical concepts about transformation, reflection, rotation, and translation. They claim that these tools may assist students in getting unique opportunities to make mathematics more enjoyable, engaging, and applicable. At the same time, it improves their interest in culture through mathematics.

D'Entremont (2015) is the next author who advocates for culture and community-based mathematics. He wrote the article "Importance of Linking Mathematics, Culture, and Community". In this article, he mentions that one can teach symmetry and transformation concepts (reflection, rotation, translation) by employing the quilt's batik patterns to the students using their culture.

In this connection, Orey and Rosa (2021) and Gueudet and Trouche (2009) assert that learners have a way to experience. They don't just abstractly learn mathematics for a deeper understanding but also allow learners to familiarize themselves with their part of the world. On the other hand, Barton et al. (2006) claim this is the teaching and learning process in connection with historical tradition. Mathematics practices in school become essential for the students' cultural reproduction and knowledge growth. Supporting the views above, Narulita et al. (2019) contend that Eurocentric knowledge needs to be linked to formal mathematical calculations in school to make students' learning more dynamic. Mathematics can be learned effectively if it is related to everyday life experiences.

After reviewing the work of different authors and long years of experience, it can be said that in the application of cultural heritage dynamically from the ethnomathematics perspective in the classroom, Nepalese teachers require long-term re-orientation and practical training on a large scale for capacity-building through experienced trainers in the same field.

In this context, Bonapace and Sestini (2003) claim that arts, including painting, sculpture, and architecture in Nepali temples, are inextricably tied to two major Indian continental religions, Buddhism and Hinduism. This shows that Nepalese indigenous culture has a unique blend of artistic design that identifies the mathematics in the Hindu culture and religion (Lévi,1905). As the largest ethnic group in Nepal, Hindus are rich in their cultural heritage around religious places. They work on arts and architecture. These are artistically designed and serve at special ceremonies and festivals. The materials, such as pillars with animals as well as bells, golden spires, roof design, and architecture carved on wooden patterns on beams, windows, and doors, also reflect the religious history and practices of mathematics. These works are the basic ideology of ethnomathematics practices.

However, over the years, mathematics has been viewed as a culture-free subject (Pathuddin & Nawawi, 2021; Rosa & Orey, 2011) as these resources traditionally showed only the usual meaning in the temples. The purpose of teaching, especially in Nepal, was to deliver and solve mathematical problems guided by textbooks, keeping the curriculum as the center that has stressed 'continuing to control students for appropriate understanding' (Luitel, 2009; Wagley et al., 2008) rather than the teaching and learning mathematics related to students' local use temple arts, architectural, materials, and shapes. Reviewing the above past works of literature, I learned that if students get a chance to learn mathematics by connecting with local and religious practices, they will be motivated to creative learning.

On the other hand, mathematics educators and teachers unanimously opine that school mathematics is the foundation for the higher-level study required to make meaningful learning applicable to the student's real life. However, it's very hard to find mathematics teachers at school who connect cultural/ religious heritage as a source to give an abstract concept. According to the Education Review Office Report (ERO) [(ERO), 2019], this is one of the reasons for students' poor performance in grade 5 as studied by the National Assessment of Student Achievement (NASA) in different terminal exams. This made this researcher realize that the lack of connection with the local/ religious practices and contextual activities in mathematics teaching and learning in the classroom is also one reason to encourage students to use meaningless rote in shapes, facts, and formulae. Therefore, the link with local knowledge may solve it (Ernest, 1996). On the other hand, researchers also find that research hardly captures and incorporates mathematical knowledge from a Hindu temple. Changu Narayan used arts and architecture as the ethnomathematics perspective, which is an essential issue in the Nepalese context.

Hence, this research aims to answer the following questions: What mathematical shapes, concepts, knowledge, and ideas are embedded in the traditional temple Changu Narayan? and how can temple-used arts, architecture, and materials be used in teaching and learning as excellent resources in school mathematics in the Nepali context? That will also give great significance for further research in the local context.

Methods

In this research, the researcher used descriptive ethnography qualitative research methods to describe the mathematical ideas and provide answers to the question on inherent cultural/ religious art, architecture, carved wood, and their used materials in the Nepalese context (Reeves et al., 2013; Sulasteri et al., 2020). Data collection techniques that the researcher used are participant observation, electronic devices such as smartphones, cameras, documentation, and journals as the descriptive data. The field notes and field records were also collected. This study's priority is to obtain inductive views of the informants from available information. The research approach has been explained descriptively, where the researcher tries to generate the mathematics concept based on the field data and documentation. Data analysis was done by data reduction, which means researchers wrote and collected all the results of the field data as well as summarized, selected, and sorted out the essential photos, documentation, and things and analyzed them. The researchers conducted a complex process of collecting and choosing the correct information into one systematic, more straightforward, more selective form to understand the meaning quickly. Finally, the researcher concluded from the field data, documentation, and different kinds of literature. The stages of determining the value of mathematics are carried out in the following manner: The first researcher reviewed the literature on various types of traditional Hindu temple art and architecture, shapes, materials, and carved wooden designs and linked the mathematical concepts with the researcher's experiences as two-decades of teaching in schools, training and researching knowledge through estimation.

Results and Discussions

From the results of ethnographic descriptive research confirmed through direct field observation at Changu Narayan Temple Bhaktapur in depth on Thursday, 14 April 2022, when celebrating Nepali New Year, the result obtained data from documentation, field photos, and images of Changu Narayan Temple associated with mathematical knowledge through the estimation, supporting data and works of literature.

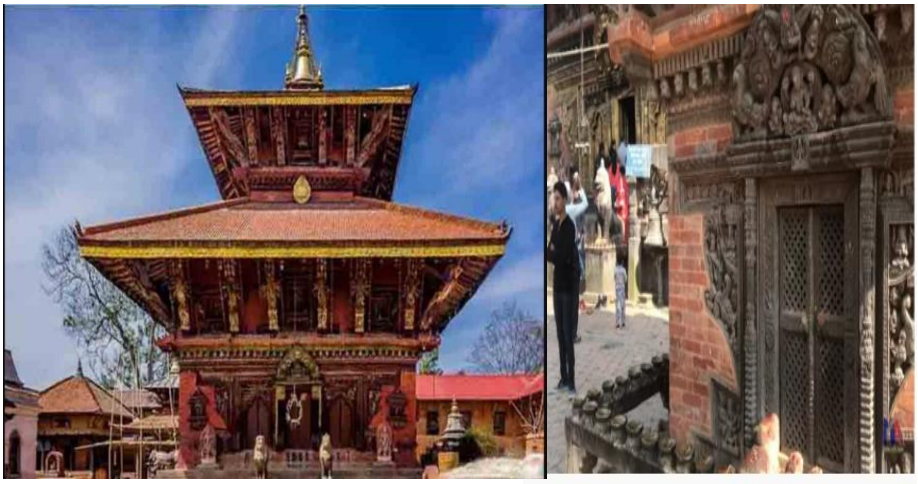


Figure 1. Changu Narayan Temple Front View Photo and its Carved Wooden Window

Hence, interesting mathematical concepts in 2D and 3D shapes were found in geometry and mensuration, such as congruence and similar isosceles trapezium, rhombus, semi-circle and circle, circular and rectangular base pyramids, lines, angles, and concepts. The roof of Changu Narayan Temple, their used design of arts, architecture, carved wooden windows, and doors can be seen in Figure 1.

The several mathematical concepts and ideas that overcame the shape of the roof of Changu Narayan Temple, its top pinnacle, Ghanti (Bell), and its used arts, architecture, and carving design on the wood are presented below.

2D and 3D Shapes on Geometry and Mensuration Concepts

The two-story traditional roof of Changu Narayan temple is the finest example of the Nepali temple architectural design that was built in the "popular Nepalies" on a one-tied brick – platform. It also has a sculpture lip and a pandan-style roof. Its top roof is made from gilded copper sheets, while the lower one has a traditional tiled roof. On every four sides of both roofs, the congruent isosceles trapezium is applied on its lower and top roofs, as shown in Figure 2.

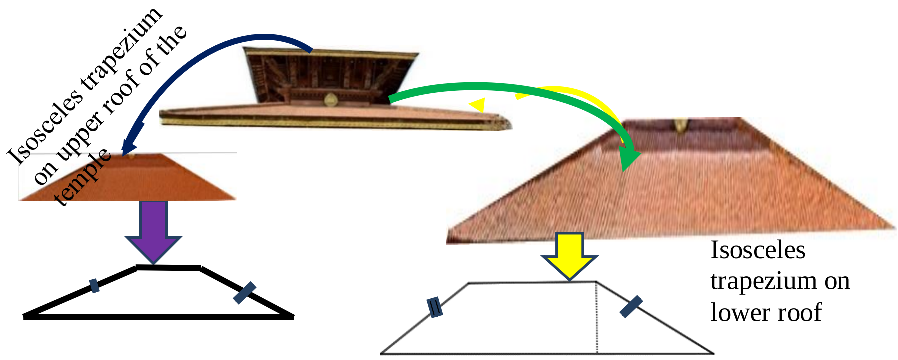


Figure 1. Isosceles Trapeziums on the Top and Lower copper sheets in the tiled roof of the Temple

Figure 2 shows the top and lower roofs of the Changu Narayan temple, a pair of similar isosceles trapeziums with one pair of their opposite sides being parallel. The areas covered by the front face of the top and lower roof of the temple can be calculated by using the formula ½ (sum of the length of parallel sides) × height, where height can be measured by the perpendicular distance between the two parallel top and bottom copper sheets and the tiled roof of the lower one. These two trapeziums should have proportional corresponding sides, and corresponding angles are found to be equal. The sum of all the angles of each trapezium is 360 degrees. Trapeziums have two types based on scalene: isosceles and isosceles trapezium. Each type of trapezium in Euclid geometry has its unique characteristics (Hartshorne, 2013). The form of the trapeziums on the top roof and lower roof of the Changu Narayan Temple is an isosceles trapezium. This concept is concerned with Euclid's geometry. That concept can be taught by students at the primary and secondary levels of mathematics in geometry and measurement.

Semi-Circle, Area, and Perimeter Concept from Woodcarving Window

We found expert craftsmen in the woodcarving tradition of Silapakar families in the Kathmandu

Valley, particularly in the Bhaktapur area, and still, such skills peoples have remained. However, over the last two generations, groups have specialized in producing wooden decorative pieces for religious temples, new houses, and hotels for commercial carving for tourism and furniture production 7(Bonapace & Sestini, 2003). However, in the Changu Narayan temple windows, we can see a highly refined woodcarving tradition designed by expert craftsman Silpakar. This traditional wood carving design is remarkable since it combines multiple areas, such as art and design, with some mathematical sense and adds to the culture's values. It may be applied in different branches of mathematics, such as geometry, mensuration, and transformation, at the same time in a dancing manner.

Consequently, such designed windows of temple structures with a lot of mathematical significance might be proof of context for teaching and learning different branches in the classroom. However, just as an example, the author has mentioned one example, taking only its semicircular shape. The top part of the window woodcarving tradition, highlighted by yellow, can be applied to teach and learn the mathematical concept of a semi-circle and its perimeter in school, as shown in Figure 3.

Figure 3. Front View Photo of Wood Carving Window and Craftsmen Activities

Figure 3 shows the highly refined woodcarving on the window of the Changu Narayan temple. The top part of the highlighted shape in Figure 3 shows the mathematical concept of a semi-circle in detail in Figure 4. This concept has been clearly addressed in the school mathematics curriculum at the primary level to grades nine and ten. These shapes of the figures can be applied to learn the mathematical concept of the circle, diameter, perimeter, and its areas in school mathematics. In Figure 4, the woodcarving on the top shape is semi-circular. Its diameter is denoted by the researcher by "d" units. Its perimeter (P) = $\pi\frac{d}{2} + d \quad + d$, and area can be calculated using the formula (A)= $\frac{1}{2}\pi\left(\frac{d}{2}\right)^2$ sq units. Hence, Figure 4 shows that wood carving on the window carries several meanings, including geometry, measurement, logic, reasoning, skills, and art.

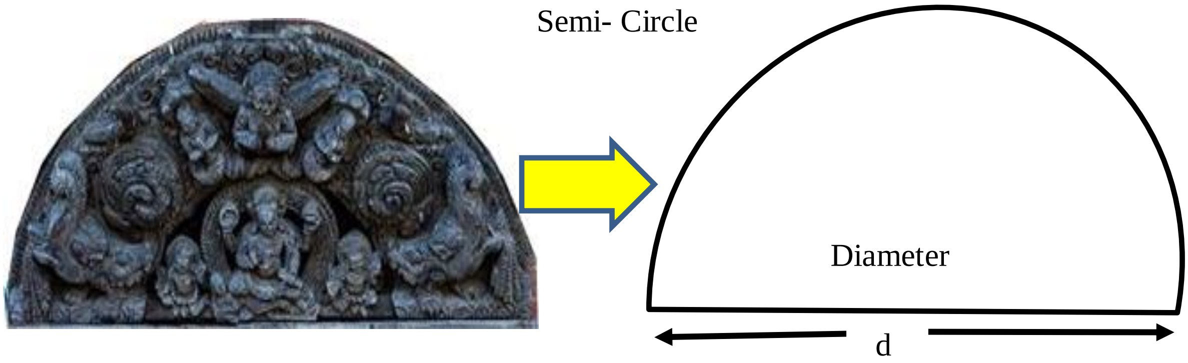


Figure 4. Mathematical Concept Semicircle from Top Part of Window

It is a real-life blend of art and mathematics that may be used to teach many areas of mathematics like reflection, translation, rotation, curves, time and work, ratio and proportion, set, and many other concepts in the classroom. However, the researcher has addressed only the circle shape in this paper, as shown in Figure 4. Using its shape, the teacher can teach students the concepts about radius, diameter, semi-circle, semi-perimeter, and area in mensuration areas.

3D Right Circular Cone on Top of Golden Gajur (Pinnacle)

The top part of the Golden Gajur (Pinnacle) of Changu Narayan temple can be seen as a right circular cone. Figure 5 shows the application of the concept of the right circular cone using the golden gajur (Pinnacle) of the temple. For this, the researcher constructed right circular cones in the world with vertical height denoted by 'h', and the radius of the base of the circular part is 'r', which is similar to the shape of the top of the Gagur of the temple. Similarly, the researcher constructed the yellow 3D shape of the right circular cone through a computer and Dynamic Geometry Software GeoGebra, which is shown in Figure 5.

Hence, in Figure 5, if its vertical height is denoted by (h), slant height is by 'l', and its radius is by 'r'. Its curved surface area, total surface area, and volume can be calculated by using the following formula: Curved Surface Area (C.S.A) = πrl sq. units; Total Surface Areas (T.S.A) = $\pi r^2 + \pi r l$ sq. units and Volume(V)= $\pi r^2 h$ cub units. This concept is also addressed in Euclid's Geometry at the Secondary Level, which the teacher can use in the classroom to teach the cone in lower and secondary-level mathematics in mensuration areas and volume.

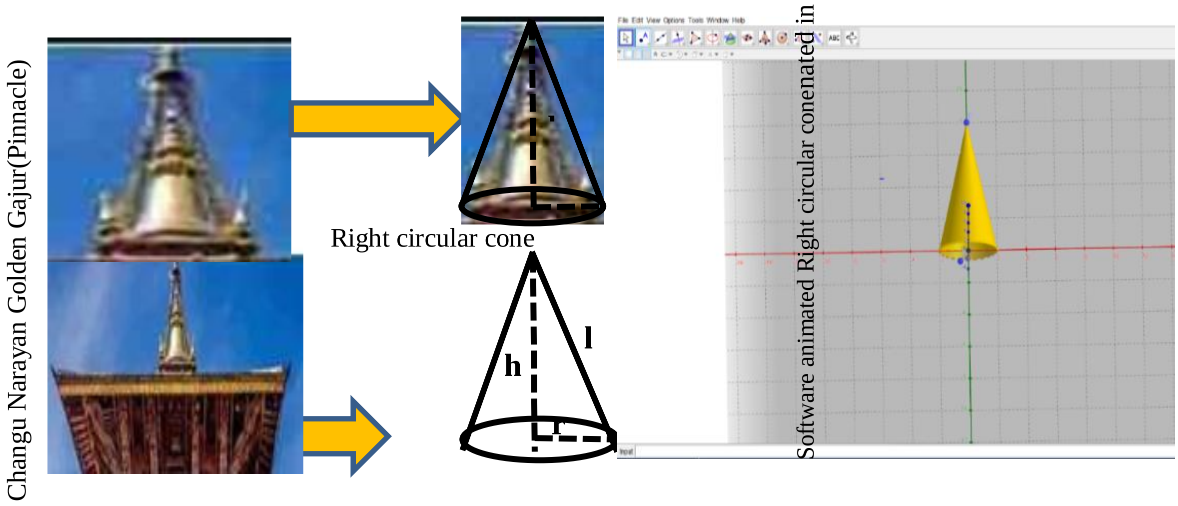
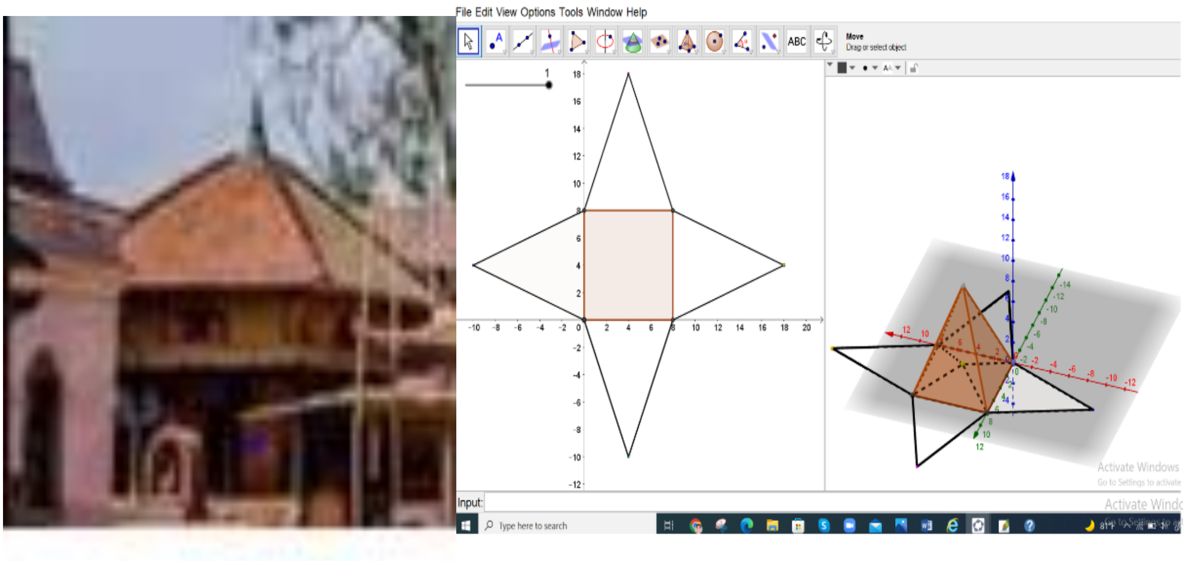


Figure 5. 3D Shape Right Circular Cone in Golden Gajur (Pinnacle)

Four Isosceles Lateral Triangles of Rectangular-Based Pyramid

A rectangular base pyramid with four lateral triangular faces can be seen in the top part of the temple below in Figure 6, which is very close to the main temple of Changu Narayan. The lateral four triangular faces on the top roof of the temple meet at the common point of the button of the top pinnacle. When the edges of each face meet at the vertex, they form a triangle. Therefore, on the top roof, we can see the four isosceles lateral triangles, and they meet at the common vertex of the lower part of the Gaguar, which we can consider the vertex. However, the researcher drew a rectangle-base pyramid with isosceles lateral triangular faces using GeoGebra Mathematics software, which is shown in Figure 6.



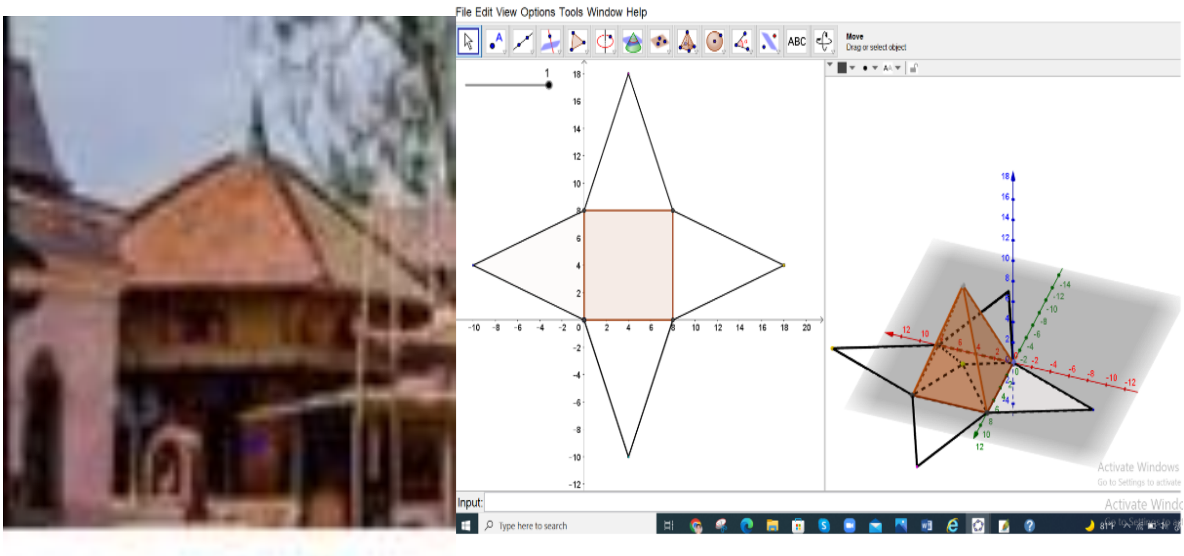


Figure 6. Changu Narayan Temple: Shape of Rectangular-Based Pyramid

This concept can be used in the classroom to teach and learn rectangular-based pyramids, volumes, total surface areas, and lateral surface areas, as well as to apply the concept of the pyramid and their nets. This also carries a lot of geometrical meanings that can provide a rich context in the classroom teaching and learning of mathematics. So, constructing temples in the surroundings is understanding rectangular-based pyramids in school mathematics from a local setting that provides immediate contexts for students' lives.

Mathematics from Ghanti/ Ring Bell

Ghanti (Ring Bell) is called a Sanskrit and is vital in the spiritual seat and invocation of gods and goddesses. Nepalese bells are unique in shape and size. During a visit to temples and puja ceremonies, we witnessed the bell ringing, which plays a pivotal role in healing our body, mind, and soul and giving us the human verse of scriptures. In my experience, before worshiping them in temples or beginning a puja ritual at a temple or home, we often ring the bell as a sign to invoke God and goodness (Bonapace & Sestini, 2003). While ringing, the bell produces a divine sound, which creates positive vibrations around the place. The bell's body has a different meaning than Ananta in Sanskrit, while the tongue of the Ghanti represents goodness, Saraswati.

The handle of the bell represents Hanuman, Garuda, Nandi. That is considered to be essential for energy and is known as Prana Shakti. With the sound of Ghanti while ringing, we will not only gain the life energy and human verse of scriptures, but the shape of the ringing bell of the temple is applied to understand mathematical concepts such as triangle, base in the shape of the circle, the bell has curve, arc, and concept of the circular based pyramid. In Figure 7**,** the researcher also drew the imaginary curve lines using the bell that was used in the Changu Narayan Temple.

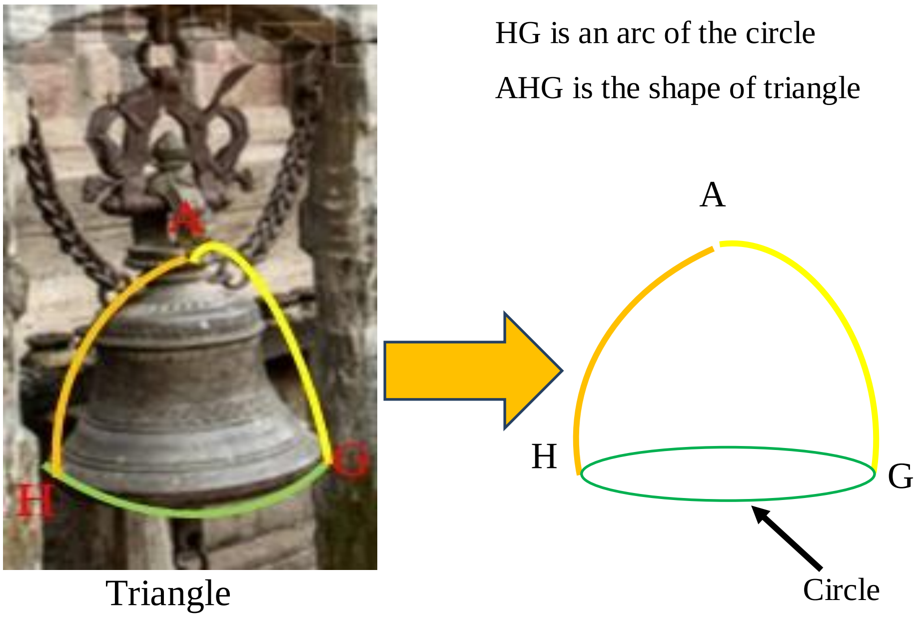


Figure 7. Bronze Bell or Ghanti in Changu Narayan Temple

Circle, Arc, and Cuboid and Rhombus from Stones Stele Design on Changu Narayan Temple

Stones are used in Hindu temples. Steles have a square shape and rise from a stone foundation with a symbolic stone image of the universe, commonly the tortoise (Bonapace & Sestini, 2003). A lotus blossom capital is usually seen at the summit of the pillar, on which a bronze statue is mounted (can be seen in Figure 8). At the top of the pillar is typically a lotus flower capital, on which a bronze statue is placed. There are unique arts and mathematics together in the temple. The statue is usually of a king or an important symbolic figure like the Garuda.

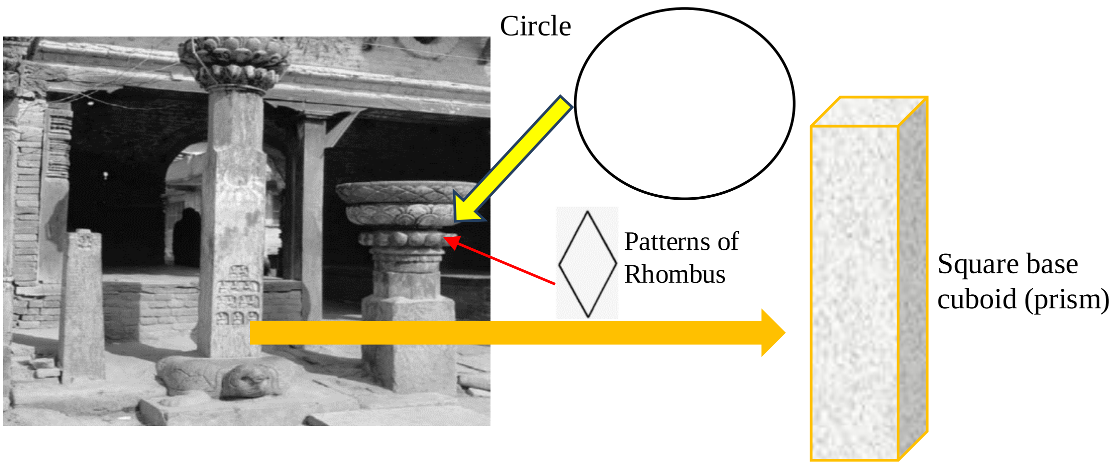


Figure 8. Beautiful Arts on Stones Stele Changu Narayan Temple

The Stones Stele also depicts the beautiful art patterns of a congruent rhombus (see Figure 8). Therefore, we can link many mathematical concepts in mensuration using these shapes. However, the researcher has addressed the idea of the circle, square-based cuboid (prism), and patterns of congruent rhombus patterns, shown in Figure 8.

All in One Mathematics: From Changu Narayan Temple Windows

In the window design of wood and Stones Stele, beautiful mathematics can be seen in various geometry areas. There, we can find beautiful mathematics in multiple fields, such as algebra, arithmetic, geometry, and mensuration. Silpakars are the craftsmen whose wood design art in Bhaktapur Changu Narayan Temple has great mathematical significance. Their designs of differently shaped windows impart the concept of arithmetic multiplication Table 2, the arithmetic sequence with first common difference 2 and quadratic sequence with second common difference 1. multiplication table can be seen in arithmetic areas 2, area and perimeter, calculation of combined solid semicircle and rectangle, sectors, intersecting lines, parallel lines, vertically opposite angles, corresponding angles, line of symmetry, and concept of parallelogram and areas using the aankhijhyal holes that have shown in Figure 9.

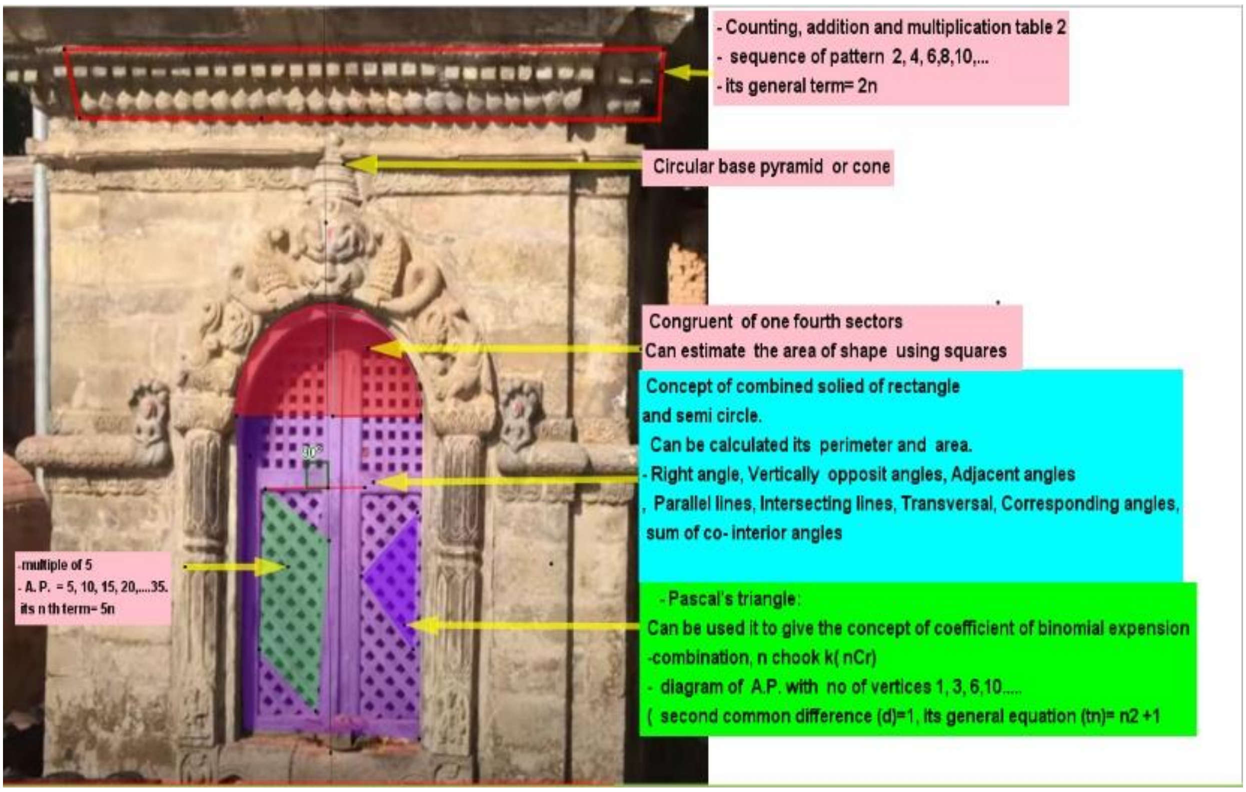


Figure 9. Changuran Window: Wonderful Sources for Multi Areas of Mathematics

This depicts that children can also bring a lot of local issues of application of mathematics from their community using local temples and household practices to the classroom that can help students understand the value of learning mathematics and make learning mathematics exciting and fun.

The results of this exploratory qualitative research study contribute to complementing several previous studies (Examples, Arisetyawan et al., 2014: Study of ethnomathematics : A Lesson from the

Baduy Culture; Pradhan, 2017; Sharma & Orey, 2017: Meaningful mathematics through the use of cultural artifacts; Wagley et al., 2008: Developing culturally contextualized mathematics resource materials: capturing local practices of Tamang and Gopali communities" that have examined ethnomathematics from various cultures in Nepal.

Similarly, from the international context, Ethnomathematics from the perspective of Sundanese (Abdullah, 2017); Learning geometry and values from patterns: ethnomathematics on the Batik Patterns of Yogyakarta (Prahmana & D'Ambrosio, 2020); and Pranatamangsa System and the Birth-Death Ceremonial in Yogyakarta (Prahmana et al., 2021). Further, the result of Narulita et al. (2019) shows that a traditional *wayang* art performance in Surakarta, The Stones Stele, depicts the beautiful art patterns of a congruent contains ethnomathematics that can be used as a source of learning mathematics modulo 9, 2, the geometry of space, even-odd number, rectangle, and circle. Hence, these findings can add new mathematics knowledge together and can be generated using their ethnocultural practices connecting with cultural-based contexts from local and global perspectives. Nepalese art is such that it can be used for students to learn meaningful mathematics, connecting the students 'real-life experiences and daily activities with the communities' cultural practices. To know the correct shapes of 3D, GeoGebra software also can be used as a teaching tool to draw flexible and accurate geometry and mensuration shapes.

The issue is how Nepali mathematics teachers and students in formal schooling can utilize and combine the matter formally to be supplied to the culture of mathematical calculations with mathematics software that has been attached to the community to make learning more dynamic. Therefore, mathematics can be made more attractive, learned with fun, and made more accessible to understand because students do not feel unfamiliar with the habits of everyday society (Abdullah, 2017). Bonotto (2007) viewed that the cultural heritage, their used artifacts which reflect the cultural identity of different groups of peoples, ideas, and their used materials can be introduced and embedded into the classroom practices in mathematics mediated to the teaching of mathematical knowledge which learners typically meet in real life situations such cultural artifacts for teaching school mathematics to develop knowledge, ability, and competency suggested by Pradhan (2018) in the Nepali Context.

Conclusion

The result of the study and field experiences revealed that the Hindu Temple Changu Narayan used arts, architecture, carved wooden patterns on doors and windows, cuppers used in the roof, and construction design containing geometry and mensuration concepts and knowledge. 2D-related shapes and concepts (for example, similar trapeziums, congruent rhombus, circle, arc, combined solid of semicircle and rectangle, triangle areas and perimeter) and 3D-shapes (like a right circular cone, rectangular-based pyramid, and square-based cuboid or prism) were found on the top roof and lower roof of the temple, pinnacle, ghanti, stone steel and arts of carving wood window of the Changu Narayan Temple. GeoGebra mathematics software can be used to construct correct shapes found in Temple.

Based on these findings, it was concluded that the famous and beautiful temple used arts, carving patterns, and materials that can be blended to teach and learn school mathematics in geometry and mensuration, making sense of connecting local knowledge and global knowledge from in the geolocalization Changu Narayan Temple uses arts, artifacts, and materials that are used not only as perfect resources in teaching and learning school mathematics in different branches these are also equally important to save and transform the historical religious activities. However, mathematics teachers require the reorientation program in the Nepalese context.

This study has implications for teachers and students who want to teach and learn mathematics by connecting religious practices in the temple as resources through diverse ways of mathematical thinking, reasoning, and developing knowledge. The result of this study can be used as a reference to establish learning subjects and create an ethnomathematics product on temples used in arts so that it can significantly affect the learning achievement in school mathematics, geometry, and mensuration of various school-level students.

Acknowledgments

While completing this research, the researcher received a lot of guidance and support from various parties. The researcher thanks all those who have helped and given frequent suggestions and feedback, especially 1)—the head of the Changu Narayan Temple, Newari local peoples, and helpers of the temples. Hopefully, the results of this research will become a valuable work and a historical record for readers. In particular, Nepalese mathematics teachers and students in the Kathmandu Valley can implement local cultural values and spiritual knowledge together with the mathematics learning platform.

Declarations

Author Contribution	:	KDP: Conceptualization, Writing - Original Draft, Editing and Visualization, Writing - Review & Editing, Formal analysis, and Methodology Validation and Supervision
Conflict of Interest	:	The authors declare no conflict of interest.

References

Abdullah, A. S. (2017). Ethnomathematics in perspective of sundanese culture. *Journal on Mathematics Education*, *8*(1), 1-16.

Apriandi, D., & Ayuningtyas, A. D. (2022). Mathematics Teaching Materials Based on the Ethnomathematics of Shiva Temple by Applying the "Tri-N" Teaching. AL-ISHLAH: *Jurnal Pendidikan. 14(*2), 1597-1606.

Arisetyawan, A., Suryadi, D., Herman, T., Rahmat, C., & No, J. D. S. (2014). Study of Ethnomathematics: A lesson from the Baduy Culture. *International Journal of Education and Research, 2*(10), 681-688.

Barton, B., Poisard, C., & Domite, M. D. C. (2006). Cultural connections and mathematical manipulations. *For the Learning of Mathematics*, *26(*2), 21-24.

Bonapace, C., & Sestini, V. (2003). *Traditional materials and construction technologies used in the Kathmandu valley* (p. 180). Paris: United Nations Educational, Scientific and Cultural Organization.

Bonotto, C. (2007). How to replace word problems with activities of realistic mathematical modelling. *In Modelling and applications in mathematics education*: *The 14th ICMI Study* (pp. 185-192). Boston, MA: Springer US.

D'Ambrosio, U. (1989). A Research Program and a Course in the History of Mathematics: Ethnomathematics. *Historia Mathematica, 16*(3), 285–287.

d'Entremont., Y. (2015). Linking mathematics, culture, and community. *Procedia - Social and Behavioral Sciences*, 174 (2015).

D'Ambrosio, U. (1990). The role of mathematics education in building a democratic and just society. *For the Learning of Mathematics, 10*(3), 20-23.

Ernest, P. (1996). Popularization: myths, massmedia and modernism. In *International Handbook of Mathematics Education: Part 1* (pp. 785-817). Dordrecht: Springer Netherlands.

ERO. (2019). Report of National Assessment of Student Achievement (NASA) 2018 (Grade 5: Mathematics and Nepali). Sanothimi: Education Review Office. Sanothimi

Fitrianawati, M., Sintawati, M., Marsigit, M., & Retnowati, E. (2020). Developing ethnomatematics in geometry learning for elementary schools students: A preliminary design*. International Journal of Scientific and Technology Research, 9*(1), 2754-2758.

Gueudet, G., & Trouche, L. (2009). Towards new documentation systems for mathematics teachers?. *Educational studies in mathematics, 71*, 199-218.

Hartshorne, R. (2013). Geometry: Euclid and beyond. Springer Science & Business Media.

Johnson, J. D., Smail, L., Corey, D., & Jarrah, A. M. (2022). Using Bayesian networks to provide educational implications: Mobile learning and ethnomathematics to improve sustainability in mathematics education. *Sustainability, 14*(10), 5897.

Lévi, S., 1905, Le Népal: Étude historique d'un royaume hindou, Paris.

Luitel, B. C. (2009). *Culture, worldview, and transformative philosophy of mathematics education in Nepal: A cultural-philosophical inquiry*. (Doctoral dissertation, Curtin University).

Mania, S., & Alam, S. (2021). Teachers' perception toward the use of ethnomathematics approach in teaching math. *International Journal of Education in Mathematics, Science and Technology, 9*(2), 282-298.

Marsigit, dkk (2014). Pengembangan Perangkat Pembelajaran Etnomatematika untuk Meningkatkan Kompetensi Mahasiswa Pendidikan Matematikall Jurdikmat FMIPA.UNY

Muhtadi, D., & Prahmana, R. C. I. (2017). Sundanese Ethnomathematics: Mathematical Activities in Estimating, Measuring, and Making Patterns. *Journal on Mathematics Education, 8*(2), 185-198.

Narulita, D., Mardiyana, M., & Saputro, D. R. S. (2019). Ethnomathematics in Traditional Wayang Performance in Surakarta as a Source of Mathematics Learning in Junior High School. *Budapest Int. Res. Critics Linguist. Educ. J, 2*(2), 115-122.

Okyere, M. (2022). Culturally Responsive Teaching Through the Adinkra Symbols of Ghana and its Impact on Students' Mathematics Proficiency.

Orey, D. C., & Rosa, M. (2010). Ethnomodeling: a pedagogical action for uncovering ethnomathematical practices.

Orey, D. C., & Rosa, M. (2020). Positionality and creating dialogue in Nepal: connecting ethnomathematics and modelling-the importance of place through ethnomodelling.

Orey, D. C., & Rosa, M. (2021). Ethnomodelling as a glocalization process of mathematical practices through cultural dynamism. *The Mathematics Enthusiast, 18*(3), 439-468.

Pathuddin, H., & Nawawi, M. I. (2021). Buginese Ethnomathematics: Barongko Cake Explorations as Mathematics Learning Resources. *Journal on Mathematics Education, 12*(2), 295-312.

Pradhan, J. B. (2017). Mathematical ideas in Chundara culture: Unfolding a Nepalese teaching and learning system. *Ethnomathematics and its diverse approaches for mathematics education*, 125-152.

Pradhan, J. B. (2018). Mathematical ideas in cultural artefacts: A metaphor for teaching of school mathematics. *International Journal of Scientific and Research Publications, 8*(9), 335-341.

Prahmana, R. C. I., & D'Ambrosio, U. (2020). Learning Geometry and Values from Patterns: Ethnomathematics on the Batik Patterns of Yogyakarta, Indonesia. *Journal on Mathematics Education, 11*(3), 439-456.

Prahmana, R.C.I., Yunianto, W., Rosa, M., & Orey, D.C. (2021). Ethnomathematics: Pranatamangsa System and the Birth-Death Ceremonial in Yogyakarta. *Journal on Mathematics Education, 12*(1), 93-112.

Reeves, S., Peller, J., Goldman, J., & Kitto, S. (2013). Ethnography in qualitative educational research: AMEE Guide No. 80. *Medical teacher, 35*(8), e1365-e1379.

Rosa, M., & Orey, D. (2011). Ethnomathematics: the cultural aspects of mathematics. Revista Latinoamericana de Etnomatemática: *Perspectivas Socioculturales de La Educación Matemática, 4*(2), 32-54.

Rosa, M., & Orey, D. (2011). Ethnomathematics: the cultural aspects of mathematics. Revista Latinoamericana de Etnomatemática: *Perspectivas Socioculturales de La Educación Matemática, 4*(2), 32-54.

Sharma, T., & Orey, D. C. (2017). Meaningful mathematics through the use of cultural artifacts. *Ethnomathematics and its Diverse Approaches for Mathematics Education,* 153-179.

Shilpakar, R., Maskey, P. N., & Silpakar, P. (2021). Construction technology of multi-tiered temples and their rehabilitation after 2015 April Earthquake in Bhaktapur. *Progress in Disaster Science, 10*, 100177.

Sulasteri, S., Nur, F., & Kusumayanti, A. (2020). Ethnomathematics: The exploration of learning geometry at Fort Rotterdam of Makassar. *In Proceedings of the International Conference on Mathematics and Islam (ICMIs 2018)* (pp. 151-157).

Turan, S., & Matteson, S. M. (2021). Middle school mathematics classrooms practice based on 5E instructional model. *International Journal of Education in Mathematics, Science and Technology, 9*(1), 22-39.

Wagley, M. P., Sharma, T. N., Koirala, B. N., Ramos, S. Y., Taylor, P. C., Luitel, B. C., ... & Bhandari, U. (2008). *Developing culturally contextualised mathematics resource materials: capturing local practices of Tamang and Gopali communities*.