Ethno-mathematics

Mathematics Embedded in the Traditional Activities of Kumhar Community of the Varanasi District

HARISH PANDEY* AND ANJALI BAJPAI**

ABSTRACT

Various cultural groups have their specific ways of acquiring the useable functional mathematics. They unconsciously apply mathematical skills in their everyday life without realising its significance. Position Paper of National Focus Group on Teaching of Mathematics, NCERT, New Delhi, states that in Indian villages, it is commonly seen that people who are not formally educated use many modes of mental mathematics. These practices of mathematics at local level may be treated as indigenous, oral (vedic), hidden (frozen), and folk mathematics. These different concepts are a part of ethno-mathematics and provide a right of practice to every individual. This paper looks at mathematics used by Kumhar (also known as Prajapati) community, involved in their traditional activities like pot making, carving and selling in different areas of Varanasi district of Uttar Pradesh state. This paper will discuss the steps involved, things used and pattern followed in different types of practices used in pot making and the mathematics embedded in it like the concepts of angle, geometry, mensuration, symmetry, sequencing, Operations Research, reasoning, spiral, conic section, etc. An interview schedule having questions from five areas— biographic information, traditional activities, logic used and Culture, inventory control, and marketing is used and an observation was made for each practices in a naturalistic setting to gather the evidences. Results have implications for teaching of mathematics in a cultural context.

Keywords: *Ethno-mathematics, kumhar community, vedic and frozen mathematics.*

सार

विभिन्न सांस्कृतिक समूहों के पास प्रयोज्य कार्यात्मक गणित प्राप्त करने के अपने विशिष्ट तरीके हैं। वे अनजाने में गणितीय कौशलों का अपने दैनंदिन जीवन में उपयोग करते हैं।

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एनसीईआरटी, नई दिल्ली के नेशनल फोकस ग्रुप के टीचिंग ऑफ मैथेमेटिक्स के ऊपर पोजिशन पेपर में कहा गया है कि भारतीय गांवों में आमतौर पर देखा जाता है कि औपचारिक रूप से शिक्षित नहीं होते हुए भी गणित का उपयोग कई तरीकों से करते हैं। स्थानीय स्तर पर गणित की इन प्रथाओं को स्वदेशी, मौखिक (वैदिक), अप्रत्यक्ष (अवरूद्ध) और लोक गणित के रूप में माना जा सकता है। ये विभिन्न अवधारणाएं एथनो-गणित का एक भाग हैं और प्रत्येक व्यक्ति को अभ्यास का अधिकार प्रदान करती हैं। यह लेख कुम्हार (जिसे प्रजापति के नाम से भी जाना जाता है) द्वारा प्रयुक्त गणित के अध्ययन पर आधारित है, जो उत्तर प्रदेश राज्य के वाराणसी जिले के विभिन्न क्षेत्रों में मिट्टी के बर्तन बनाने, नक्काशी और बेचने जैसी अपनी पारंपरिक गतिविधियों में पारंगत हैं। इस लेख में मिट्टी के बर्तन बनाने में प्रयुक्त विभिन्न प्रकार के अभ्यासों में शामिल चरणों, उपयोग की गई चीजों और पैटर्न तथा इसमें सन्निहित गणितीय संप्रत्यय जैसे कि कोण, ज्यामिति, मैन्सुरेशन, समरूपता, अनुक्रमण, संक्रियात्मक अनुसंधान, तर्क, सर्पिल, शांकव खंड आदि की अवधारणाओं पर चर्चा की गई है। अध्ययन में एक पंच भागीय साक्षात्कार अनुसूची; जीवन-संबंधी जानकारी, पारंपरिक गतिविधियाँ, प्रयुक्त तर्क और संस्कृति, माल नियंत्रण, और विपणन का उपयोग किया गया। साथ ही सूचनाओं को इकट्ठा करने के लिए एवं प्राकृतिक सेटिंग में क्रियाकलापों के अध्ययन के लिए एक अवलोकन अनुसूची का प्रयोग किया गया। परिणामों का निहितार्थ एक सांस्कृतिक संदर्भ में निहित जानकारी का गणित शिक्षण में उपयोग पर बल देता है।

Introduction

The word ethno-mathematics has two parts 'ethno' and 'mathematics'—To understand its etymological meaning we can consider these words separately and then together. The word 'mathematics' comes from Greek term '*mathema*' which means knowledge, study, learning, science and arts. The Greek prefix 'ethnos' stands for a group of people living together. This can be explained as something belonging to a particular social group or ethnic group. This is only etymological description of ethno-mathematics, practically the word ethno refers to the specific working process to solve the problem and the second term refers to the logical terms and conditions used to arrive at the result of the problem.

The Brazilian Educator and Mathematician Ubiratan D'Ambrosio introduced the word ethno-mathematics to the world in 1977, after launching his ethno-mathematicalprogram as a methodology to track and analyse the processes of generation, transmission, diffusion and institutionalisation of mathematical knowledge in diverse cultural systems or groups (D'Ambrosio, 1985, 1990, 2001). While using the word for the first time D'Ambrosio

(1985) expressed that 'the term requires a dynamic interpretation because it describes concepts that are themselves neither rigid nor singular namely, ethno and mathematics'. The term ethno describes, 'all of the ingredients that make up the cultural identity of a group— language, codes, values, jargon, beliefs, food and dress, habits, and physical traits.' Mathematics expresses a 'broad view of mathematics which includes ciphering, arithmetic, classifying, ordering, inferring, and modeling'. In contrast to 'academic mathematics', i.e., the mathematics which is taught, practiced and learned in schools and universities, D'Ambrosio called it ethno-mathematics. He expressed that so many children fail in mathematics due to, "the mechanism of schooling that replaces these practices by other equivalent practices which have acquired the status of mathematics, and have been expropriated in their original forms and returned in a codified version".

D'Ambrosio, while giving its first definition stated, "Ethno-mathematics is the mathematics which is practiced among identifiable cultural groups such as tribe societies, labour groups, children of certain age brackets and professional classes". Ethno-mathematics explores the diverse expressions of mathematical ideas. Now-a-days it also involves the deliberations on issues related to society and culture and their impact on teaching and learning. The consonance of Ethno-mathematics and mathematics education goes to explore the fact that mathematics learning is a cultural and social process.

Apart from the above ethno-mathematics may also be introduced as part of cultural and traditional practices. 'Ethno-mathematics can be understood as the region of intersection between cultural anthropology and academic mathematics that utilised mathematical

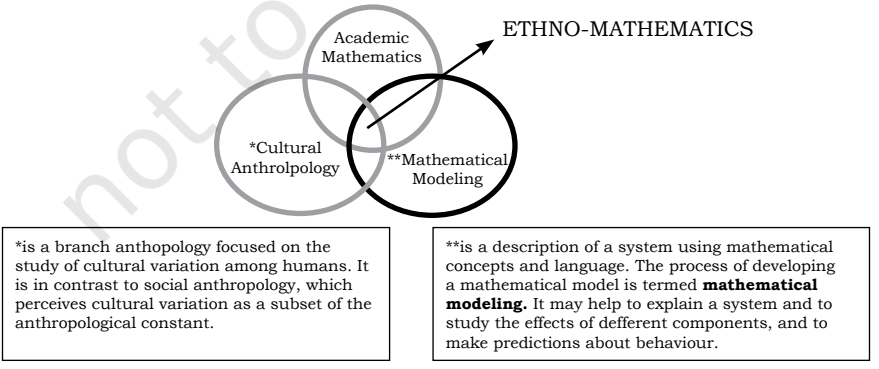


Figure 1 : Concept of the Ethno-mathematics

modeling to solve the problem taken from reality' (D'Ambrosio, 1990 and Rosa, 2010, cited in, Abiam *et.al.* 2016). Figure 1 depicts it clearly.

In India, few researches have been done in this area though our country contains high level of social-cultural diversity and mathematical practices. Some eminent scholars and institutions are working in this area. Information Technology (IT) Education department of International Institute of Information Technology (IIIT) Hyderabad, India has developed a tool to teach fractions; based on ethno-mathematics principle. Gupta (2009) used many riddles from stories and instances to solve the reasoning problems in mathematics.

Background of the Study

The study is based on the investigator's doctoral work on the topic *'Ethno-mathematics: An Investigation of an Approach for Teaching Learning Mathematics (TLM) from the Traditional Activities of the Kumhar Community of Varanasi District'*. The study was conducted on Kumhars classified as Other Backward Community (OBC), in Varanasi district of Uttar Pradesh. An economically middle class and politically active community, women also play a significant role in family (Kotte and Surendra, 2016). In their Anthropological Study, Kotte and Surendra (2016) introduced many other names of Kumhar like Prajapati, Kummar, Machavaram, Mannepalli, Pathipati, Kulluru, Chejerla, Kondapati, Chirivella and Yadavalli in relation to different cultural and linguistic profile.

Ascher (1991) stated in his study that people are unconsciously applying mathematical skills in everyday life without realising its importance. There is a great probability that such skills, if incorporated in teaching learning practices in schools could advance the outcomes of learning mathematics. The main reason behind taught mathematics at schools is to sharpen real life practices such as counting, ordering, sorting, measuring, weighing, etc. Therefore, the skills of those applying mathematics in their cultures, without any formalised training, could contribute positively towards improving performance by the learners in the classroom (Bishop, 1988; Gerdes, 1996; Zaslavsky, 1975).

Mogege (1999) investigated the relationships between cultural games and the teaching and learning of mathematics. The main aim of his work was to look at various cultural and traditional games that are found in different cultural settings, with a view towards

making use of these games in the mathematics classroom. Likewise, Gerdes (2000) noted that one of the principles of good teaching is to give importance of understanding the cultural background of the pupils and relating the teaching and learning process to it. He enlisted some non-academic aspects of academic mathematics, like socio, informal, folk, hidden, and oral mathematics. Bishop (2002), observed that every classroom now a days is characterised by the ethnical, linguistic, gender, social and cultural diversity. Teachers should have to deal with the existing cultural diversity since mathematics is defined as human and cultural knowledge deeply in comparison to any other field of knowledge. Significant effect of ethno-mathematics approach on students achievement and interest in geometry and mensuration has been reported (Kurumeh, 2004; Abiam *et al.*, 2016). Both the studies were carried out in Nigeria and approaches were developed from cultural experiences and observations. Kurumeh developed the approach from the culture of Nasukka area of Nigeria and suggested the useful aspects of Indigenous Mathematics to the curriculum planner, policy makers and administrators of the Nigeria. Abiam *et al.* (2016) recommended that ethno-mathematics based instructional approach should be adopted in the teaching of geometry. Hara-Gaes (2005) investigated the mathematics embedded in the cultural activities of the Damara people in the Khorixas areas of Namibia in real setting. He traced out many mathematical concepts from the traditional activities, house construction, sewing place and others. He also investigated the concepts of measuring, triangles, breadth, length, equality and counting from their activities.

The Indian curriculum reforms (i.e., *National Curriculum Framework, 2005*) also suggested the need for developing the ability for mathematisation in the child. The Position Paper of the National Focus Group on Teaching of Mathematics (2006, p. 11) indicates many problems regarding teaching-learning of mathematics, such as students fear and failure, phobia, boring classroom setting, disappointing curriculum, traditional ways of teaching mathematics, etc., and further provided many recommendations to solve these hurdles. One of the recommendations was to enable children to the relate mathematics to people's lives. Position paper states that in Indian villages, it is commonly seen that people who are not formally educated use many modes of mental mathematics, it may also be called folk algorithms. The study was conducted on the Kumhar community who use lots of mathematical concepts in their work.

Description of Keywords

Ethno-mathematics: Ethno-mathematics is the study of mathematics as embedded in the cultural and traditional activities of the Kumhar community of Varanasi district.

Kumhar and Kumhar Community: Kumhar belongs to the Hindu religion, caste wise they belong to Other Backward Class (OBC) by the Government of India. Kumhar is also known as Prajapati in Varanasi district. Kumhar live as a community and are involved in their traditional activities like pot making, carving and selling in different areas of Varanasi district (Sankuldhara, Kandawa, Naibasti and Tarna). In this paper researcher has used evidences form Naibasti area of Varanasi district.

Traditional Activities: The indigenous practices and procedures of the Kumhar community adopted by their forefathers and practiced in their cultural, communal or professional activities will be treated as the traditional activities of the Kumar community of Varanasi district.

Objectives

The present study aimed to identify the mathematical concepts embedded in the traditional activities of the Kumhar community of Varanasi district.

Method

The method of research used in this study was mainly qualitative in nature with naturalistic inquiry of ethnographic approach.

Sample

The research was conducted on the Kumhar community of Nai Basti area of Pandeypur region *of* Varanasi district of Uttar Pradesh. The observation was made on eleven families who lived as a community. These Kumhar families were identified through snowball sampling technique. Eighteen people of these families, who were involved in the traditional pot making, were selected purposively for the interview.

Tools

Observation schedule and self made semi-structured interview schedule were used for collecting the data. Interview schedule contained four sub areas, *i.e.,* Biographic Information, Traditional

activities, mathematics (logic) and culture, *marketing* related to the Kumhar community. Digital camera and video recorder were also used for data recording.

Miles and Huberman (1994) model of qualitative data analysis technique was used to draw inference from the collected evidences. The obtained evidences through observation and interview were analysed in three steps as shown in the Figure 2. The first step, i.e., data reduction was related with the simplifying, abstracting, and transforming the data that appears from the field notes with a view to make the information intelligible. For example, there were many other evidences of ethnophysics in query making but the investigator has not mentioned it. The second step was matrix display and examination, used to provide an organised and compressed collection of information that permits conclusion drawing and verification. All four areas of information taken from interview were displayed and organised well to complete this step. Last step was related to give common statement for displayed data and assess their implications for the research question, 'What type of mathematical concepts areembedded in the traditional activities of the Kumhar Community of Varanasi district?'

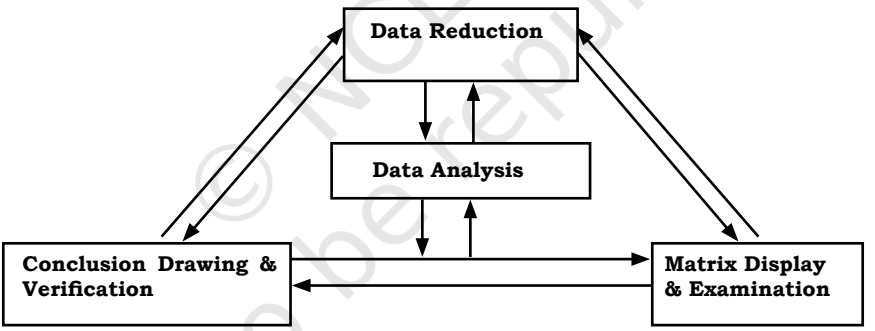


Figure 2 : Data Analysis Cycle

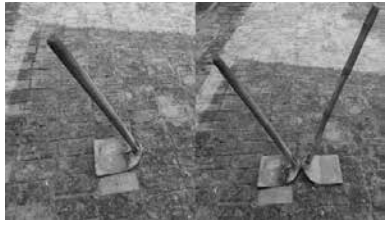
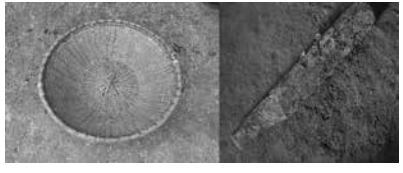
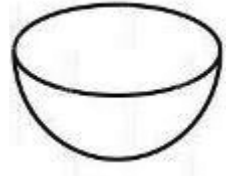
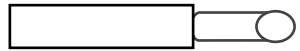
Results and Discussion

The study aimed to describe the mathematical concepts embedded in the traditional activities of Kumhar community. Based on the information obtained from all the respondents and observation by the investigator, the several activities and different types of pots were identified as mathematical evidences. The evidences of procedure of making pots, tools used and other information regarding marketing and storing have been discussed with collaborators and mathematics education practitioners.

Table 1

Identification of Mathematics Embedded in Traditional Activities of Kumhar Community

On the basis of the information about the Kumhar community based on observation and interview researcher identified these following fundamental mathematical concepts.

Tools Used or Traditional Activities	**Reflections of Kumhar Community and Researcher (Analysis and Inference)**	**Mathematical concepts imbedded/Outcomes (with some conditions)**
1. Tools a) *Fawda* (Hoe/Spade), *Khanchi* (Bucket), *Mungri* and *Patiya* (Slab):  *Figure 3, (a): Fawda*  *Figure 3, (b): Khanchi (Bucket); (c) Mungri*	Figure 3 (a) shows the image of *fawda*. As per the need, the *Kumhar* use this tool for digging, collecting soil from the field or pond and also use it in purification of the soil from granule. Their sizes may differ according to the use of different people of family. The *fawda* has two parts vertical (handle) part is made up of wood and horizontal part (base) made up of rectangular iron sheet. The measured angle between horizontal and vertical side was found from 450 to 600. It has a simple mathematical structure but the logics used for making it are very much affiliated to the concept of angle. They always fix the angle of its handle, below 900, i.e., between 450 to 600 so that they can use it easily and make it more useful and productive for their work. The researcher rotated this tool by keeping its base fixed at a point in clock wise or anti-clock wise manner and found the concept of supplementary angle. For example; if the angle between height and base is 600 after rotation it changes to 1200. With this tool and this supported activity we can explain the concept of angle and supplementary angle. *Khanchi* (Bucket), *mungri* and *patiya* (Slab) is used for loading, rubbing and spreading the soil respectively. *Khanchi* is a hemispherical handmade container used for soil loading. Observation of some *khanchi* were done by the researcher and found that 35–40 kg of soil *Kumhar* can load in it. Its a hemispharical shape with depth 20–25 cm. Approximetly all people of kumhar community had crude idea about these measures but some student member of community had specific knowledge about fromula and concept of volume (V = (2 / 3) π r3). *Mungri* is just like a cricket bat, Figure 3 (C & C1) used for rubing the hard soil. After making soil powder they spread a layer at a slab called *Patiya* (a rectangular slab). This process of spreading the soil can be explained as an example of area of rectangle. The community members had better knowledge about how much soil will be sufficent to cover the slab of perticular leangth and width, Figure 3 (C2). This shows the presence of concept of area. During obeservation of another family the researcher asked in different ways about the concept of area. For Instance; if we draw a line at the middle of the slab then how much soil would you need to spread? They replied after thinking and disscussion, 'Half of the previous amount'. This was an another evidence of their understanding of area without using any formula like exb. Most of the family uses thread to find out the length and width of the slab and other tools.	Angle ∟ Supplementary angle. Concept of volume (V = (2 / 3) π r3),  *Figure 3 (b1): Hemisphere*  *Figure 3 (c1): Rectangular and cylindrical shape* Length (l), width(b), Area = lxb  *Figure 3 (c2): Concept of area*

b) *Chaak*

Figure 4 (a); Kumhar people rotating the Chaak

2. Traditional activities or procedures: With the help of the above tools (contained at point 1.) the people of Kumhar community are involved in making different pots and decorative items. Some of them were identified by the researcher:

a) Kneading, making paste and carving:

Figure 5 (a); Kneading (b); Making Paste

Chaak is the main tool used by the Kumhar Community. Without *chaak* we can't imagine the existence of Kumhar community and their traditional activities. *Chaak* is like a flywheel, Kumhar people used to fixes its center on a spike to achieve smooth rotation. They use wooden rod to rotate it. In the given figure 4 (a), A Kumhar is rotating the Chaak with the help of a rod. They rotate it approximately 30–45 second to achieve an adequate rotational motion.

Researcher had asked many questions regarding this activity of rotating the *chaak* and observed it carefully. They told that only one reason to rotate the *chaak* was for pot making. Regarding this some questions were asked to them, what's the logic to set a particular angle between rod and *chaak* during rotation? How do you assess about the particular speed of the *chaak*, that this particular speed will enough to perform the particular activity? On the basis of the responses of the above questions it was concluded that, 'Kumhar set the angle only to achieve a particular rotational motion, for initiating the motion the rod was kept vertical to chaak's surface just like to draw a perpendicular on a plane. Logic behind speed was only that high speed for heavy pot and normal speed for light pot. For making more useful for teaching-learning mathematics the researcher has applied some conditions with *chaak* that if we draw a circle with its diameters we can able to understand the different concept of angle from 00 to 360o as shows in figure 4(b). Its rotational process (Clock and Anti-Clock wise), complimentary, supplementary, acute, right, obtuse, straight and reflex angle can be taught with the help of this tool.'

Figure 5(a), shows a *Kumhar* woman involved in kneading or making the paste of soil for pot making. *Kumhar* people told that they prepare this paste if they have unavailability of pond clay. Before kneading *kumhars* use good ratio of soil and water. Generally this work has been done by the children or women member of the family but for adding water in soil the experienced member of the family perform their role. Because the experienced member have good estimate about the ratio of water and soil. Different family had different making procedure but one thing was observed similar that if they had to prepare one *khanchi* (bucket) clay they added approximately one fourth water in one bucket soil. This refers that the ratio between soil and water added was 4:1. They had inherent knowledge about ratio but they were not aware of mathematical concept of this. When the researcher asked a counter question that if we change the order of these added substances then what will happen? They replied that either we add soil in water or water in soil the outcomes will remain unchanged. This shows that they practices commutative law. (for a defined operation)

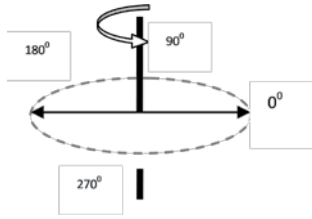


Figure 4 (b): Concept of 0 to 360 degree

Drawing perpendicular (⊥) on a plan from any point.

Concept of Angle from 00 to 3600 from a single *chaak* and its rotational process. (Clock-wise & Anti-clock wise) Complimentary, supplementary, acute, right, obtuse, straight and reflex angle.

Concept of ratio.
Commutative law of mathematics, i.e., A+B = B+A
For example:
Soil + Water = Water + Soil
(For making specific Paste with Defined operations)

They also used associative law of mathematics, i.e., A+(B+C) = (A+B)+C
They draw many patters that are very similar to the mathematical diagrams for drawing colouring and finding area and perimeter, etc.

Figure 5 (c): Carving

Figure 5 (d): Symmetrical Patterns

After making and baking the pots *Kumhar* people prepare a specific colour paste with the help of the soil, water and bark of *catechu* (*kathha*/ *khair*), Figure 5(b). First of all they boil bark of *catechu* and filter it and then use filtered liquid, i.e., *khair* in colour making. Therefore, only three things were mixed (Soil+ water+ *khair*) for simple colouring.

Another family, which had larger business of pots making, prepare these colours differently. As per information provided by them, for preparing colour for 500 *Matkis* of 2 litre they mixed 100 gm *khair*, 50 gm caustic soda, 250 gm powder of bark of mango tree and 2 kg soil.

Here in both evidences it was discussed about the sequencing of added materials and association of one material with rest of the materials. Researcher found that the practices were based on commutative law as well as association also. For example: Soil + (Water + *Khair*) =(Soil + Water) + *Khair*

Kumhar people prepare colours for painting and carving the pots with different traditional diagrams and patterns. Figure 5(c) Shows that a *Kumhar* women involved in painting and carving the pots. They generally use brown colour for painting and white colour (lime/chuna) for carving. The intensity/saturation of colour depends upon the amount of *khair* and water added in the mixture. *Kumhar* people draw indigenous diagrams and patterns on the pots, figure 5(d). Most of the patterns were simple and circular. For example: In figure 5(d), this is a painted *matki*. The line at the bottom of matki is circular, in the middle it is curvy and at the top it is again similar as bottom line and also parallel. It's showing a structure of line and parallel line.

Further at the top of the *matki* the worked pattern is just like a peacock feather. If we draw a straight line at the mid of this structure. It will divide this structure into two symmetrical parts, Figure 5 (d1). This shows the concept of symmetry in patterns.

The concept of symmetry

Drawing Lines (circular/ parallel).

Concept of symmetry

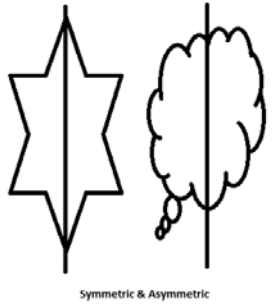


Figure 5 (d1): Symmetry and Asymmetry

b) Making different types of pots: *Kulhad*, *Gamla*, *Matki*, *Deepak*, etc.

Figure 6 (a): Kulhad

The peoples of Kumhar community were following several activities for different needs of pot making, carving, etc. The making of these items is a taking procedure hence the researcher has observed only some of them. Figure 6 (a), shows a *kulhad*, which is used to serve tea in Indian local cultural environment. Its structure is like a conical frustum but it may be different in shape and size. It was measured that every *kulhad* of small size had approximately equal height, weight and water containing efficiency. How that was happening with this activity while they were not used any unit measure norm during process of *kulhad* making? It was happening because of their good estimating power and experience. With the help of this pot we can explain the concept of volume and height, width, latent height, circular bottom etc., and also can use as an example in teaching learning mensuration.

Every step for making pot has a specific logic and some mathematical concepts. Understanding elementary shapes, geometry and practical geometry, concept of symmetry, Visualising solids and shapes, Some concepts of Mensuration

Figure 6 (b): Gamla (Flowerpot)

Figure 6 (c): Matki (Pitcher)

Figure 6 (b), shows *gamla*, it is used mainly for gardening of flowers and light trees. Procedure for making this pot is similar as *Kulhad* but it is large in shape and size. The *Kumhar* people after rotating the *chaak* drag the clay in upward direction with the help of thumb, index and middle figure. Sometimes use proper hand to maintain the shape of the pot and after getting an adequate size cut the pot with a thread. It was observed that the truncation procedure of both *kulhad* and *gamla* are very much similar as the frustum of cone.

Figure 6 (c), shows *matki* (Pitcher), which is mainly used as a water container. Its making procedure was complex but due to lack of proper observation researcher cannot explain clearly. This can be used as a teaching-learning material for explaining the concept of hollow sphere.

The steps involved in making of all these items has a specific type of logic and have some mathematical concepts like understanding elementary shapes, geometry and practical geometry, concept of symmetry, visualising solids and shapes, some concepts of mensuration, area volume, height, lateral height, comparison of shapes and quantities can also be seen.

(Area volume, height, lateral height)
Frustum of cone
concept of hollow sphere.
comparison of shapes and quantities.

b) Cutting the pots from *Chaak*:

Figure 7 (a): Cutting

Figure 7 (b) Spiral type structure

Figure 8 (a): step 1 and 2

Cutting/truncating the pots from *chaak* is a technique as well as skill also. They use a small thread for cutting, Figure 7 (a). During observation it was evident that the base of *kulhad* has a specific geometrical structure. When it was asked to *kumhar* people they told that this is a circular shape, due to friction between thread and base of *kulhad* it is generated. But it can be seen in Figure 7 (b) its structure is like a spiral. Because of circular motion of *chaak* and friction with thread this curve has made up. In mathematics this shape is called spiral (r (t)=1/t or 1/√t).

On the basis of above analysis, interpretation of making procedures of pots as shows in Figure 6 (a), (b) & 7 (a), (b) an another concept can be drawn with the help of some conditions. Let us suppose in the cutting process of *kulhad* and *gamla* if we consider it as right circular cone and change the angle of truncation we can find different kind of geometrical structures, Figure 7 (c).

With applying some conditions we can generate the different concepts for teaching learning mathematics.

Anwan is an oven or kiln used to fire the pots. The process of preparing *anwan* was observed keenly by the researcher and for better understanding its working procedure has broken in six steps, Figure 8 (a b and c). *Kumhar* people prepare a hole in the ground. Generally the shape of ground hole was hemispherical. Some families were made it rectangular also. They prepare *anwan* for baking the pots as per their space and need. They arrange iron rods as a grill at the upper surface of the ground so that the space behind rods can remain for firing and proper air flow.

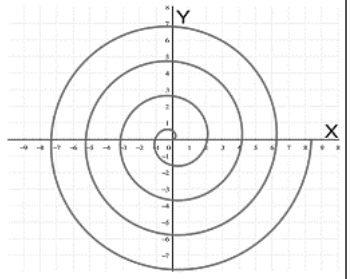


Figure 7 (b1): Shape of spiral

Conic section; circle (1), ellipse(2), parabola(3), hyperbola(4)

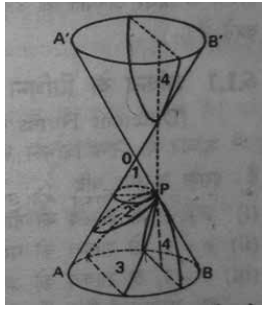


Figure 7 (c): Conic Section

The mathematical concept of sequencing, forward and reverse counting, arrangement of different types of a shapes, concept of reversibility 1>2>3>4...= 4>3>2>1, and

 *Figure 8 (b): Steps 4 and 5*  *Figure 8 (c): step 5 and 6*	After that they cover the grill with husk, dung, straw and coal, Figure 8(a): Step 1 and 2. After that they count and arrange the all unbaked pots upon it with specific steps, i.e., large pots in first few rows and smaller pots in the last few rows, Figure 8 (b): Step 3 and 4. It shows the concept of sequencing and the concept of reversibility embedded in it. At every step they make a layer of dry grass and coal powder. After completing the last step *Kumhar* people make a plaster upon the arranged pots with clay, slurry and straw, Figure 8 (c); step 5. Further burn the anwan from bottom side and leave it for baking for six to eight hours. In this process of making *anwan*, *Kumhar* people use ethnophysics rather than ethno-mathematics. For example; the baking/firing process of *anwan* is very much isolated in nature. But the logics used to prepare it are more mathematical. After firing *Kumhar* people excluded the pots from ash in a sequence (last row first and first row in the last), Figure 8 (c); Step 6. Here, the process of exclusion can be used as an example of last in first out and first in last out in Q-theory.	Q-theory (first in-first out/last in-first out and first in-last out) of operations research are embedded in this activity of *Kumhar* community.
3. Marketting/Selling: to offer people to buy something	Marketing is related to the ultimate aim of their practices because all the activities which are conducted are there because of public demand. The educational status of *Kumhar* people is not so satisfactory that they can organise their work and products at higher level of marketing but they use indigenous practices to perform their marketing process (Kotte and Surendra, 2016). It was asked to them, How do you calculate the price of the pots? All people had no any idea for this question but some experienced members who were not very educated had the knowledge about estimation of price. For example one member explained it as, "The price of the pots depends on the price of coal because we buy it from market and rest of the things used in making and baking are homemade. So if we have to make 4000 *kulhad* and the price of coal per Kg are ₹60 4–6 kg coal used for one time *Anwan* preparation. Let us suppose other material used is of ₹100 And day wise labour is ₹300 (keep in mind that for making ₹4000 *kulhad* the 3–4 days expended) Then, ₹360 (for coal) + ₹100 (for other things)+ ₹1200 (labour) = ₹1660/-	Concept of estimation of price, Concept of Profit and lose, Unitary method.

	So, ₹416 for 1000 of *kulhad* and approximately ₹42 for 100 *kulhad* and ₹4 16 *paisa* for 10 *kulhad*." After that he discussed the profit behind their selling that, "if the amount spent will be more than the selling then our business will be in loss and if not, then it will be in profit." Here it can be conclude that they have the concept of estimation of the price which they calculate it by a base unit of 10, 100, and 1000 and also concept of profit. Similarly, one woman member of a family has discussed and calculated the price of one *kulhad* for selling. It was evident that she also used the concept of Unitary method as a technique for solving a problem by first finding the value of a single *Kulhad* then applying it to all.	

Educational Implication: This study highlights the useful aspects of cultural mathematics and traditional practices of Kumhar community to the curriculum planer and textbook writers in Indian school setting. This will also enhance teachers to adopt innovative strategies of teaching mathematics to learners. All mathematical concepts stated in Table can be used for teaching-learning of mathematics and some points can be specified as:

- The mathematics embedded in the tools used by the *Kumhar* community can be used as an example during teaching the concept of angle, supplementary angle, concept of volume, length, width, and area. Further rectangular, cylindrical and spherical shapes can also be introduced.
- From the use of a model of *Chaak* or with discussion the circular motion of the *Chaak*, the teachers can develop the concept of 00 to 3600 in the students, also the concepts of acute, obtuse, straight and reflex angle.
- The mathematics teacher can use the process of kneading and making paste for color as an example of commutative and associative law. The concept of symmetry can also be developed from carving done on the pots by the *Kumhar*.
- The different types of pots can be used as an example of identification of geometrical shapes.
- Preparation of anwan includes many scientific steps; some of them can be elaborated with students for teaching 'sequencing the things' at lower classes.
- Kumhar Community has indigenous knowledge about estimation of price of the pots, unitary method and profit-loss. The mathematical problems of profit-loss can be framed by using the practices of *Kumhar* people.

Conclusion

The National Curriculum Framework (NCF, 2005) has suggested the need for developing the ability for mathematisation in the child and provided many recommendations to solve the hurdles and one of them is to enable children to observe the relevance of mathematics to people's lives. This paper is also reflecting the same ideas and advocates multi-cultural and ethnomathematical aspect of teaching learning mathematics from Kumhar community. On the basis of the above discussions and analysis we can conclude that if in a single community like Kumhar, these several mathematical

concepts are embedded, then in the country like India where the huge cultural diversity exists, such type of investigations are needed. Many people are unconsciously applying mathematical skills in everyday life without realising its importance. There are great probabilities that such skills, if transferred to schools, could advance the teaching and learning of mathematics. Therefore, the skills of those people who applying mathematics in their cultures without any formalised training, could contribute positively towards better performance of the learners in the classroom.

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