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Ethnomathematics Approach — A Culture based Pedagogy

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Abstract

Ethnomathematics refers to the relationship between mathematics and culture. Different cultural and ethnic groups have their specific ways at practical mathematics. People, belonging to these groups, unconsciously apply varied mathematical skills in their daily lives without realising their importance. The Position Paper of the National Focus Group on Teaching of Mathematics published by the National Council of Educational Research and Training (NCERT), New Delhi, states that in Indian villages, it is common that people, who do not attend formal school, apply different mathematical practices or modes (mental maths) in their day-to-day lives. These mathematical practices at the local level may be treated as indigenous, oral (Vedic), hidden (frozen) and folk in nature. This paper provides a conceptual framework of 'ethnomathematics'. It discusses how ethnomathematics, as a sub-field of mathematics education, deals with cultural diversity. It underlines the relevance of ethnomathematics as an approach of teaching–learning of mathematics through traditional activities performed by people, belonging to the Kumhar community (who traditionally practise pottery).

Introduction

The word 'ethnomathematics' was coined by Ubiratan D'Ambrosio, a Brazilian educator and mathematician, in the year 1977, after launching his ethnomathematical programme 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, 1990). In contrast to 'academic mathematics', i.e.,

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the mathematics that is taught, practised and learned in schools and universities, D'Ambrosio explained ethnomathematics as "mathematics which is practiced among identifiable cultural groups, such as national–tribal societies, labor groups, children of a certain age bracket, professional classes, and so on" (D'Ambrosio, 1985). He added that a number of 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, which have been expropriated in their original forms and returned in a codified version".

Every classroom is characterised by gender, social, cultural, ethnic and linguistic diversity. Researchers point out that general, as well as, mathematics teachers have to deal with the existing cultural diversity as mathematics is defined as a human and cultural knowledge. Ethnomathematics has, thus, become a common practice globally. Dealing with cultural diversity in classrooms is universal.

India is a country with a rich sociocultural diversity, and hence, mathematical practices. Indian ethnic groups comprise *Kumhars*, *Dharikars* (who traditionally make craft items with ropes and bamboos), carpenters (who traditionally make furniture), etc. In this paper, the researchers elaborate on the traditional activities practised by *Kumhars* and point out the relevance of ethnomathematics as an approach of teaching and learning of mathematics.

Etymology of Ethnomathematics

The word 'ethnomathematics' is composed of two Greek words — *ethno*, meaning 'race' or 'culture', and *manthanein*, meaning 'mathematics', which implies knowledge, study, learning, science and arts.

All humans study to learn, develop their own techniques and sort knowledge so as to improve their applicability in order to survive. This, etymologically, manifests that mathematics is universal in nature. However, the word, *ethnos*, which may be construed as 'belonging to a particular social or ethnic group', has a meaning of changeability or relativity, meaning it cannot be interpreted as universal like mathematics. So, 'ethnomathematics' refers to mathematics related with diverse social groups. This seems to be an oxymoron as it is contradictory to use *ethno* along with mathematics etymologically. But this is only an etymological description. Practically, the word, *ethno*, refers to a specific working process to solve a problem and 'mathematics' is the logic applied to arrive at the solution.

'Mathematics education' refers to the teaching and learning of mathematics. 'Vedic mathematics' is the mathematics based on the 16 selected formulas given in the *Vedas* (Agrawal, 2013). 'Hidden mathematics' may be defined in the words of Gerdes (2000) as, "Although, probably, the majority of mathematical knowledge of the formerly colonized peoples has been lost, one may try to reconstruct or 'unfreeze' the mathematical thinking that is 'hidden' or 'frozen' in old techniques, like that of basket making". 'Folk mathematics' (although often not recognised as such) develops in the working activity of each of the peoples and may serve as a starting point in the teaching of mathematics (Mellin-Olsen, 1986).

Relevance of Ethnomathematics as a Teaching Approach

Many people unconsciously apply mathematical skills in their daily life without realising their importance. There is a probability that such skills, if merged with school education, could advance the teaching and learning of mathematics. The main reason behind teaching mathematics in schools is to sharpen children's acumen as regards to real-life practices, such as counting, ordering, sorting, measuring, weighing, etc., (Ascher, 1991). Therefore, the skills of those applying mathematics in their cultures, without receiving formal training, may contribute towards the better performance of learners in classrooms.

The *Position Paper of the National Focus Group on Teaching of Mathematics* (NCERT, 2006) also advocates the multicultural and ethnomathematical aspects of learning mathematics with the help of few examples. In South India, one may spot *kolams* (complex designs drawn on the floor using a white powder, somewhat similar to North India's *rangoli*, which is made in different colours) at the entrance of houses. The designs, patterns and symmetries used in *kolams* are some of the points that mathematics education in schools may address. Similarly, art and architecture, and music offer intricate examples that may help children appreciate the cultural grounding of mathematics.

Also, the *National Curriculum Framework* (NCF)–2005 advocates the need for developing the ability of mathematisation in children. The *Position Paper of the National Focus Group on Teaching of Mathematics* (NCERT, 2006) indicates many problems as regards to the teaching–learning of mathematics, i.e., students' fear of failure, phobia, boring classroom setting, monotonous curriculum, conventional ways of teaching mathematics, etc., and provides several recommendations to solve these. One of the recommendations is to enable the children learn about the relevance of mathematics in real life. The Position Paper, further, states that in Indian villages, it is commonly observed that people, who are not formally educated, use many modes of mental mathematics. It may be called 'folk algorithms'.

It, therefore, shows that this culture based approach is relevant and must be used in the classrooms as 'ethnomathematical' approach of teaching.

Researchers point out that ethnomathematics creates a specific teaching environment for teachers and a special learning environment for students. So, they fail the applicability and practicality of mathematics in concrete situations. It amplifies the knowledge of the content being studied and helps the students, as well as, teachers to understand, explain and reflect upon their own thinking processes and reality.

As a culture based pedagogy

The structure and curricula of mathematics in schools do not often recognise the students' pre-school knowledge of mathematics. Moreover, they do not mention much about the history, formation, origin or culture of mathematics. They, in turn, are directed towards solving the problems by applying certain techniques and giving examples. As a result, many students fail to draw connections between academic mathematics and the real world. They view mathematics as something taught and practised only in the classrooms, schools and as home assignments.

However, if a teacher uses ethnomathematics and its principles in a classroom, the scenario will change. Unodiaku (2013), who conducted studies in a Nigerian region, found that the mean achievement scores of the students taught with ethnomathematics teaching materials were significantly higher than those taught only with conventional approach.

Ethnomathematics practised by *Kumhars*

On the basis of these pedagogies, the researchers tried to study the traditional activities practised by the *Kumhar* community and figure out the relevance of ethnomathematics as an approach to teaching and learning of mathematics.

It was observed that the *Kumhars* used a number of mathematical concepts to carry out their traditional work, i.e., pottery making. Some of them as observed and analysed by the researchers through interview and observation techniques are presented in Tables 1, 2 and 3.

Table 1: Observations on ethnomathematics as practised by *Kumhars*

Tools	Concepts	Elaboration	Activities and demonstration	Framing mathematical word problems
• *Fawda* (spade) • *Khanchi* (bucket or basket) • *Mungri* (mallet) • *Patiya* (slab) • *Pitan* (pestle) • *Chaak* (wheel)	• Angle • Supplementary angle • Circle • Rectangle • Cylinder • Disc • Hemisphere • 0° to 360° angle • One figure — two shapes • Perpendicular	• Inclination of two lines • Concept of supplementary angle • Explanation of the concept of rectangle, height, base and area • Circular disc and angle formed on it by rotating the *chaak* • How many mathematical shapes are embedded in a figure (explanation of its structure)? • Meaning of perpendicular on a plane	• Angle between the base and height of the tools used • Supplementary angle with the rotation of *fawda* or any other angle • Concept of area by spreading soil on the slab • Comparing the shape of the tools used with identical mathematical shapes • Angle formed on a circular disc by rotating the *chaak*, and making circle on the *chaak*	• What is an angle? • If 'angle' is symbolised as A=60, then supplementary angle will be ____? • Find area= l×b, for the given length and breadth. • Make different type of shapes and identify mathematical shapes formed in them, if any. • Find acute, obtuse and other type of angles (formed on a circular plane, i.e., *chaak*).

Table 2: Commonly practised ethnomathematical activities

Activities	Concepts	Elaboration	Demonstration	Mathematical problems
• Preparing the soil for kneading • Making pots • Cutting pots using a *chaak* • Making colour paste • Carving	• Examples of commutative or associative laws • Ratio or fraction (proper, improper and mixed) • Logic used • Truncation of conic section • Counting (forward and reverse) • Reversibility • Symmetry • First in last out	• Mixing soil and water, and colour making (natural number with different operations) • Explanation of A+B = B+A, and A+ (B+C) = (A+B)+C, etc. • Knowledge of the amount of water to be mixed with soil; making pots out of a given lump and fractional representation of it (1/10, 1/40, etc.); explanation of the procedure of conic section • How to make the frustum of a cone? • Arrangement, reversibility, counting and dislocating the things	• Making clay lumps (video presentation of the procedure, for example, number and type of *kulhad* pots made out of a lump) • Cutting or frustum of conic activity • Colouring • Arrangement of smaller pots in larger pots (putting *kulhad* and *deepak* in a *matki*)	• Problems on commutative and associative laws • Problems on rational fractions • Problems on circumference using paint • Arrangement of the things`
Outcome (pots) • *Kulhad* (tea cup) • *Gamla* (flower pot) • *Matki* (pot for water) • *Deepak* (clay lamp) • *Naad* (trough)	• Examples of three-dimensional shapes like cone, frustum cone, sphere, etc.	• Explanation of three-dimensional shapes (edge, vertex, side, face, circumference, volume, etc.)	• Videographical presentation of the pot making procedure as practised by the *Kumhars*	• Identification of the problem of side, face, vertex, surface area and volume

	Measures of different mathematical shapes and volume (relationship between the volumes of a cone and cylinder)	• How to construct the frustum of a cone? • How to measure height, latent height, radius, diameter, etc.? • Practical meaning of larger and smaller volume (for different things)	• Activities for the identification of different concepts of three-dimensional shapes (edge, vertex, side, face, volume and circumference) • Measurement of height, latent height, radius, diameter, etc. • Activity for water containing efficiency of the pots, i.e., volume	

Table 3: Marketing activities practised by *Kumhars*

Inventory control	Concepts	Elaboration	Activities	Mathematical problems
• Taking orders • Deciding or estimating the price • Calculating the rate (profit or loss)	• Examples of order taking • Strategy, price decision, and profit or loss • Examples of preserving techniques of the pots — unitary method	**Taking the order** • Logic used to decide the rate of the pots • Profit or loss calculation • Controlling inventory (future planning, business purpose) • Using the unitary method of calculation to fix the rate of each pottery item	• Works like taking the order, preparing pots, delivering and price calculation may be performed in class based on the activities practised by *Kumhars*.	• Problem of business planning • Problem of deciding the price, profit or loss calculation, etc. • Problems based on unitary method

Tables 1, 2 and 3, thus, present a description of the tools used and the activities performed by *Kumhars*. They also show the mathematical concepts embedded in their traditional activities.

Traditional Activities and Working Procedures

The researchers have used terms like kneading of the soil, making paste and carving to give a glimpse of the working patterns of the *Kumhars*.

Figure 1 shows kneading of the soil to make a paste for making pottery items. Kneading involves using soil and water in appropriate proportions. Kneading of the soil is, generally, done by children or women members of a family. But only an experienced person adds water to it. Different families knead the soil differently. However, one thing commonly observed is if a *Kumhar* needs to prepare one *khanchi* (bucket) of clay, one would add approximately one–fourth water to one bucket soil. This means that the ratio between soil and water is maintained at 4:1.

It has also been observed that *Kumhars* have an inherent knowledge about ratio. But they are not aware of the mathematical concept.

The respondents shared they would add more soil, if there was excess water, or more water, in case there was more soil, so that the outcome remains unchanged. This shows they practise 'commutative law' (for a defined operation).

After making and baking the pots, the *Kumhars* prepare colours for painting them. They, generally, prepare a colour paste using soil, water and bark of catechu (*kathha* or *khair*). The bark of catechu is first boiled, and then, filtered. The filtered liquid is used for making the colour. Therefore, only three things are mixed (soil, water and *khair*) for colouring.

However, a *Kumhar* family, having a bigger pottery business, prepares

Figure 1: Kneading of the soil for making pottery items

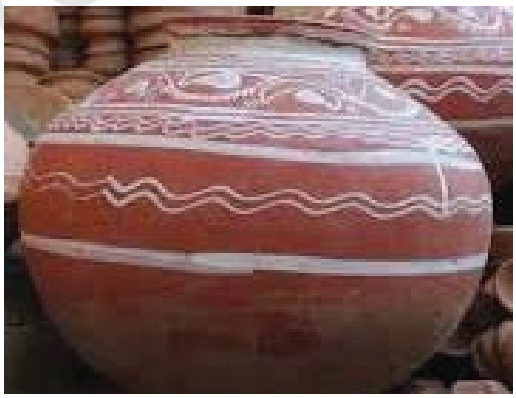

Figure 2: Kumhars, generally, use brown for painting a pot and white (lime or chuna) over the carving.

colours differently. For preparing colour for 500 *matkis* of two–litre capacity, one would, usually, mix 100 gm *khair*, 50 gm caustic soda, 250 gm mango tree bark powder with 2 kg soil.

The researchers found that the practices in both the cases were based on commutative and associative laws, for example, soil + (water + *khair*) =(Soil + water) + *khair*.

It was found that the *Kumhars*, generally, used brown for painting and white (lime or *chuna*) over the carvings (Figure 2). The intensity or saturation of the colour depends on the amount of *khair* and water added to the mixture. *Kumhars* draw indigenous designs and patterns on the pots. Most of the designs are simple and circular. The line at the bottom of a *matki* is circular; in the middle, it is curvy; and on top, it is again similar and parallel to the bottom.

Further, on top of the *matki*, the design may look like a peacock feather. If a line is drawn through the mid of the *chaak* (potter's wheel), it is observed that the structure is divided into two symmetrical parts. Figure 3 brings out the concept of symmetry as in the shape of the *chaak*.

Figure 3: Chaak (potter's wheel)

Classroom Practice and Observations

The researchers demonstrated these procedures in Class VI to impart three basic concepts of mathematics — commutative and associative laws, and symmetry. The researchers used group, pre– and post–test designs, i.e., pre–experimental design (o1-x-o2) on a group of 36 students of a local government school in Varanasi, Uttar Pradesh. For the pre–test, an achievement test with 10 items based on the concept of commutative and associative laws, and symmetry was used. The mean score of the students in the pre–test was 5.88 with the Standard Deviation (SD) recorded at 1.96. After that, classroom practice sessions based on the ethnomathematics approach that the *Kumhars* adopted was held for six days. At last, the post–test observations were recorded. The post–test mean was 8.47 and SD 1.29. The mean difference was calculated through t–test and the calculated t–value (6.57) was found significant at 0.05 level of significance. The researchers also found that the mean achievement score of the students significantly increased after using the ethnomathematics approach. So, it may be recommended that teachers can also use the ethnomathematics approach for teaching and learning of mathematics rather than only following the conventional way of teaching the subject.

Conclusion

From the cultural practices as adopted by the *Kumhar* community for the teaching–learning of mathematics, it may be concluded that there are many other ethnic groups, whose traditional practices may prove useful in the teaching of mathematics and other subjects. However, there is a need to modify the traditional activities as practised by different ethnic groups so that they may be used in the teaching–learning process in classrooms. Researches relevant to the area need to be conducted. Moreover, the identity and dignity of students coming from diverse ethnic backgrounds should be endorsed in classrooms, making it truly inclusive.

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