Mathematical Ideas in Mat Weaving: Connecting Ethnographic Field Study and Classroom Teaching

Jaya Bishnu Pradhan

Abstract

Mat weaving is one of the common activities performed in different communities, generally in the rural part of Nepal. Mat weavers practice mathematical ideas and concepts implicitly in order to perform their job. The teaching and learning of school mathematics can be enriched if the concepts are taught based on students' experiences and practices. This study was intended to uncover the mathematical ideas embedded in mat weaving that can help teachers and students in the teaching and learning of school mathematics. Ethnographic methodology was used to uncover and describe the beliefs, values, understanding, perceptions and attitudes of the mat weavers towards mathematical ideas and concepts in the process of mat weaving. A total of 4 mat weavers, 2 mathematics teachers and 12 students from grade level 8-10, who were used to participating in weaving, were selected for the study. The whole process of the mat weaving, classroom observation and in-depth interview were taken with the participants with the help of an interview guide and an observation checklist. The mathematical activities in different sectors of their lives, their ways of understanding the natural phenomena, and their ethnomathematical knowledge were analyzed with the notions of pluralism. From the field data, it was found that the mat weaver exhibited sophisticated geometrical ideas in the process of construction of frame and mat. The possibilities of incorporating these cultural activities and the pedagogical techniques were observed in the mathematics classroom. It is argued that it is possible to use mat weaving activities in the teaching and learning of school mathematics.

Keywords: culture, ethnomathematics, ethnography, indigenous knowledge, weaving

Introduction

Mathematical ideas and thinking are embedded in every environmental activity of a group of people. However, the mathematical ideas they possess in order to perform their everyday job remains largely hidden. The cultural activities of the human being invented some mathematical knowledge and concepts. Every culture has developed some mathematics practices consistent with their needs and interest for everyday activities. Naturally, it is not surprising that extremely prac-

tical concepts such as numbers and counting have arisen in all cultures. There is a lack of evidence regarding the exact date the people of the world started to weave their items. For thousands of years, people have weaved baskets, hats, mats and other items. Different cultures have carried out weaving using different materials like grass, leaves, clothes, feathers, paper and other local materials.

Bishop (1991) stated that mathematics is a cultural product, which has developed as a result of various activities, and that counting, locating, measuring, designing, playing, and explaining are all part of that cultural product. Everyday life is impregnated in the knowledge and practices of a culture. At all times, individuals are comparing, classifying, quantifying, measuring, explaining, inferring, generalizing, and evaluating, using material and intellectual instruments that belong to their culture (D'Ambrosio, 2006).

The term ethnomathematics is coined with the different perspectives. Numbers of scholars define it in different ways. Ascher and Ascher (1997) defined ethnomathematics as the study of the mathematical ideas of non-literate people. Others believed that it is the methodological postures used in the teaching and learning of formal mathematics (Ferrerira, 1989). Ethnomathematics helps to conceptualize the abstract mathematical ideas by connecting children's everyday activities. In D'Ambrosio's (2006) view, ethnomathematics is a research program about the history and philosophy of mathematics and it is also the program of the way in which cultural groups understand, articulate and use the concepts and practices, which is described as mathematical, whether or not the cultural group has a concept of mathematics. Thus, ethnomathematics is relatively new as a field of research. It may be described as the study of mathematical ideas and activities as embedded in their cultural context. Further D' Ambrosio (2006) defined ethnomathematics as "the mathematics which is practiced among identifiable cultural groups such as national-tribe societies, labor groups, children of certain age brackets and professional classes" (p. 44).

Ethnomathematics can be described as the way people from a particular culture have as common systems for dealing with quantitative, relational, and spatial aspects of their lives (Barton 1996). It follows what Knijnik (1997) describes as an ethnomathematical approach, one that is characterized by the investigation of the traditions, practices, and mathematical concepts of a subordinated social group and the pedagogical work, which was developed in order for the group to be able to interpret and decode its knowledge (as cited in Alangui, 2017).

The ethnomathematical ideas of the group of people have generally been excluded from discussions of formal and academic mathematics. Rosa and Gavarrete (2017) also viewed that their mathematical knowledge and learning approaches are not taken into consideration in the formal school mathematics curricula. The

mathematical ideas from the group of working class culture, the acknowledgment of their ways of knowledge generation and transmission, students' experiences should be blended with formal mathematics in the classrooms (Pradhan, 2017). In attempting to create and integrate mathematical materials related to different cultures and that draw on students' own experiences in an instructional mathematics curriculum, it is possible to apply ethnomathematical strategies in teaching and learning mathematics (Rosa & Gavarrete, 2017).

Pradhan (2012) conducted a study to explore the knowledge generation of *Chundara* and compare and contrast the ways they learn and teach in their everyday activities from the school pedagogy. The main finding of the study was that *Chundaras* teaching and learning activity involved participatory and cooperative approaches in which they learn with the help of their parents. Their ways of teaching and learning approach is similar to the Vygotsky's theory of Zone of Proximal Development. Millroy (1992) found a group of carpenters who used the concept of tacit knowledge of mathematical ideas. This concept of tacit knowledge implies that most people know more than they can tell. Tacit knowledge manifests itself through human activities, and is not necessarily expressed or expressible in written or spoken form. According to Millroy (1992), "the physical act of designing and building furniture would involve tacit mathematical knowledge" (p. 13). Millroy's study seeks to uncover and describe the beliefs, values, perceptions, understanding and attitudes towards the mathematical ideas in their everyday activities (Merriam, 2009). This study revealed that all cultures have basic counting, sorting and deciphering methods, and that these have arisen independently in different places around the world. This can be used to argue that these mathematical concepts are being discovered rather than created. However, others emphasize that the usefulness of mathematics is what tends to conceal its cultural constructs.

Research Questions

The main objective of this study was to explore the ethnomathematical ideas embedded in the activities in mat weaving in the rural settlements of Nepal.

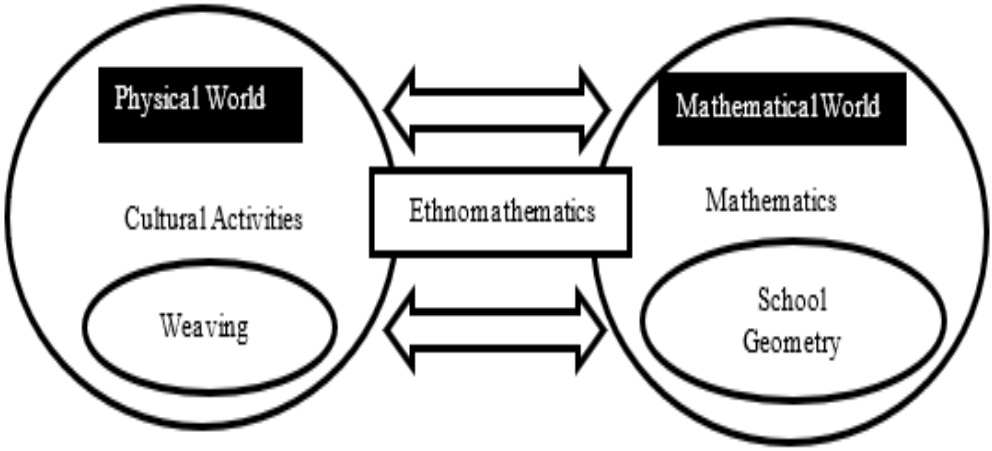
- What mathematical ideas are embedded in the mat weaving activities?
- How does weaving activities facilitate teaching and learning of school mathematics?

Conceptual Framework

The primary goal of the research objective was to connect the learners' out-of-school mathematical ideas and knowledge with the school mathematics. The conceptual framework of this study is based on the theoretical framework of the Bourdieu's cultural capital and sociocultural theory of Vygotsky. The framework developed in this research study shows how the cultural activities of weaving mats can be a mediated tool for the teaching and learning of school geometry based on a constructivist learning environment. The mathematics practiced in different cultures implicitly is known as the ethnomathematics. Ethnomathematics refers to a form of mathematics that varies as a consequence of being embedded in cultural activities whose purpose is other than doing mathematics (D'Ambrosio, 2006). People practice mathematical ideas in the process of weaving mat without knowing formal mathematics. This framework puts the ethnomathematics at the centre of two domains of physical and mathematical worlds. My argument in this study was that ethnomathematical ideas embedded in the weaving activity can be mediated to the understanding of school geometry. The mathematical understanding is important for everyone and they are using mathematical ideas and knowledge to perform everyday work. The mathematical knowledge and ideas are implicitly used in out-of-school culture.

Figure 1

Ethnomathematics: Connecting Cultural Activities and Mathematics



The learner's culture and everyday activities regarding ethnomathematical ideas is an integral part of education in general and learning mathematics in particular. This model highlighted the integration of the mathematical concepts and practices originating in the learner's culture with those of school mathematics (Adam, 2004; Alangui, 2017). It is believed that classrooms and other learning environments cannot be isolated from the communities in which they are embedded, and students come to school bringing with them values, norms and concepts they have acquired from their culture and environment. The students' home culture and ethnomathematical ideas and knowledge provides opportunities to connect to the formal mathematics. Figure 1 depicts a conceptual framework to connect the students' out-of-school knowledge, embedded mathematical ideas in their cultural activities to school mathematics. This framework allows for a wider set of student' cultural activities, which has possibility for application of formal mathematical ideas. It suggests that it is possible to connect the school mathematics without-of-school context through the ethnomathematical ideas.

Methods and Procedures

This study was intended to explore the ethnomathematical ideas in the activities of group of people and their ways to knowledge generation and distribution to their generations. To fulfil my research objective, I resolutely situated myself as a qualitative researcher. I only needed to determine the specific type of qualitative research methodology as I began to design this study. The reflectice process of choosing the most appropriate metholodgy led to mathematical idea and practices in mat weaving activities of group of people as a sociocultural process (Taylor & Bogdan, 1998). Ethnography can be a primary methodology for collecting empirical data from the field regarding the mathematical ideas, knowledge, and practices in their activities. I used ethnography to describe, interpret, and reveal the meaning of cultural activities regarding ethnomathematical ideas embedded in mat weaving. While conducting this research, I continuously addressed the questions of interest involving mathematical ideas embedded in the process of weaving mats and their ways of teaching and learning in their cultural settings. During the study of implicit mathematical ideas and thinking of mat weavers, I positioned myself to engage within the ethnographic research techniques. I chose ethnography as a research methodology because my study was intended to explore their mathematical ideas from the perspective of mat weavers (emic) and from the eyes of western mathematical perspective (etic).

The process of data collection in ethnography is extensive. Ethnography emphasized the importance of listening and asking appropriate questions, observing the day-to-day lives of the people in natural setting. Although the main data

gathering was accomplished through participant observation, interviews were also an important part of the research, with the opportunities for interviews many times occurring as a natural event, not having to be scheduled (Flick, 2006). To obtain the answer of my research questions, I purposively selected four mat weavers from the rural area of Tanahun district near a public secondary school. A total of two school mathematics teachers and 12 students, who participated in weaving activities, from basic level of education were selected for the study. The data regarding the mathematical ideas embedded in mat weaving process were collected through the observation of their activities, listening and asking appropriate questions to the group of people in natural setting. This was done with the help of interview guidelines and observation checklist. With regard to the data recording, the researcher records behavior and activities of the group of people in natural setting through field notes. The field notes included paper-pencil, photographs, video or audio recorders with the consent of the research participants. I carefully recorded all the possible conservations with the help of the video camera and took field notes as much as I could. I collected the data from the multiple sources during the course of my study. I reviewed all of the data gathered from the multiple sources of data and then organized them into categories or themes that cut across all of the data sources (Creswell, 2014). I transcribed the conversations and interviews into manuscripts so that I could easily analyze and interpret them.

After observing the data, I linked them with many possible theories to interpret them. I triangulated the data, and the theoretical closures and gave meaning to my findings. In this process, I tried to produce the accurate descriptions of the contents. Interpretation involved attaching meaning and significance to the analysis, explaining descriptive patterns, and looking for relationships and linkages among descriptive dimensions. In my study, the cultural activities in the student's community and their ways of understanding the natural phenomena, and their ethnomathematical knowledge were analyzed with the notions of pluralism. In this study, the analysis of the data was validated and made more reliable by triangulating the statements among the research participants, their ways of presenting the text in the several times of data collection periods.

Mathematical Ideas in Mat Weaving

Weaving mats is one of the common activities in the rural part of the different communities in Nepal. The weaving of both sitting mats and sleeping mats reflect the cultural values and identities. Handloom (*hataso*) is a major tool employed to weave a mat. It is rectangular parallelepiped in shape and approximately 2½ (*haat)* length (a haat = 18 inch, amal = 1 inch approximately), 3 (*amal)* breadth and 4 (*amal)* height. There are odd numbers of holes in handloom (*hataso*) and maximum number of holes is15. The distance between the holes is approximately

4 *amal*. They fix a frame for the mat with the length of 6 *haat* and the breadth of the mat is flexible as the number of holes used in the handloom (*hataso*). The mat weavers make a mat with different sizes. The size (breadth) of the mat (*Gundri*) is called '5 *Ghare*', '7 *Ghare*', '9 *Ghare*', '11 *Ghare*' etc. As per the number of holes such as 5 holes, 7 holes, 9 holes, 11 holes used in handloom (*hataso*). The breadth of the mat depends upon the length of the paddy bushes available and the length is determined on the basis of purpose of the mat weavers.

Figure 2

Villagers Weaving Mat Using Mathematical Concept



The best time to weave the mat is winter season, as it is right after the harvest of the paddy fields and the people feel free from the busy days of farming and other household chores. The women of the rural community are engaged in weaving mats because it is considered that weaving a mat is a female activity and responsibility. The weaving of a mat is a multi-step process. First of all, they make the frame in a rectangular shape with four poles. The mat weaver starts by taking four poles and two beams. The two poles are to be laid on the ground at a distance just longer than the length of the handloom (*hataso)*. And these two poles are tied together with the beam. The third pole is laid as per the length of mat required to be woven and the fourth pole is moved to form the close of a quadrilateral. The distance between the first and third pole is measured with the help of a rope. The fourth pole is further adjusted until the distance measured from the second pole become equal and the third pole and fourth pole are tied together with the beam. The mat weavers follow certain pattern and ways to weave through a straw. The strips of straw are used to weave from left to right and then from right to left parallel. Each time a strip is completely woven into the mat, it is pushed up against the previous weft strip.

The pattern is continued with each strip until all of the strips are used and then resulting mat is tight and firm.

The various mathematical ideas and thinking are inherited in the process of constructions of the mats. Indigenous people have implicit mathematical knowledge with the ability to perform a task but without the ability to explain their deeds (Pradhan, 2017). This implicit mathematical knowledge is embedded tacitly. Mosimege and Lebeta (2000) also reported that the indigenous people use different mathematical concepts like estimation, and tessellations, and symmetry in the construction of the traditions artefacts and cultural activities. Chundara people use lots of mathematical concepts and knowledge in their everyday activities. Their knowledge without sufficient justification for the rule they have been using are consistent (Pradhan, 2012). In recent years, it is generally observed that most of the cultural activities are degrading. It is because of the rapid development of science and technology and globalisation. The similar type of plastic mat and carpets, produced in a cheap costing, is on the verge of replacing the use of traditional handmade mats. The artefacts that the community members developed for their everyday use and for survival is redundant. The modernization replaces the cultural art and artefacts.

The process of construction of the mat provides opportunities to work with various geometrical concepts like measurements and pattern concepts. The knowledge they practised in the process of construction of a net of the sleeping mat is equivalent to the theorems in Euclidean geometry. The process of constructing rectangle is adjusting four corners and is termed as making *Chaukon* as the vertices. The following are the theorems embedded in their activities.

T_1: A parallelogram with equal diagonals is a rectangle.

T_2: A quadrilateral with congruent diagonals that intersects at their midpoint is a rectangle.

T_3: Opposite sides of a rectangle is equal and parallel.

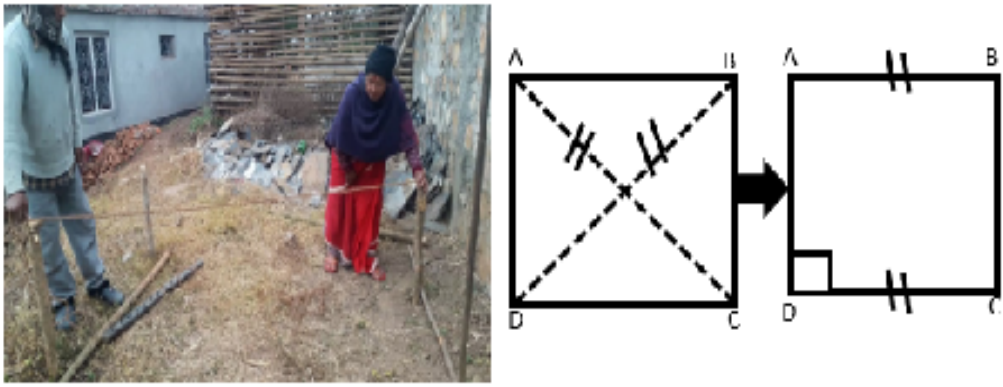
In the construction of frame to weave a mat, the mat weavers formulate the rectangle axiom: In quadrilateral ABCD, if AC = BD then it is a rectangle. The activities across the different cultural villages are largely the same as most of the indigenous people are culturally homogenous (Barton, 2008). In this regard, Gerdes (1999) mentioned that the traditional Mozambican house builders also used the similar knowledge as used by the mat weavers.

The use of x-test is to find the four points of the rectangle where they can make their pole stand for the swing. When they finish step three, they take one rope and draw a diagonal measurement of the rectangle. Whatever the length is, they mark that length and use it from the next corner. When they measure the length AC, they use the same length from B to D. Now they have, A, C and B and need to fix D as they consider three points (A, B, C) as fixed points and just to

determine the last point (D). When they do it, the problem is solved. At this time, the x-test is applied. The mat weavers do not really care about the vertices: A, B and C. They just want to fix the vertex D. They already have taken AB=CD, now they just have to make sure the x-test (AC=BD) is there. Once AC becomes equal to BD, they determine the four corners of the swing. The mathematics ideas used by mat weavers in their activities could be an ample opportunity to connect school mathematics.

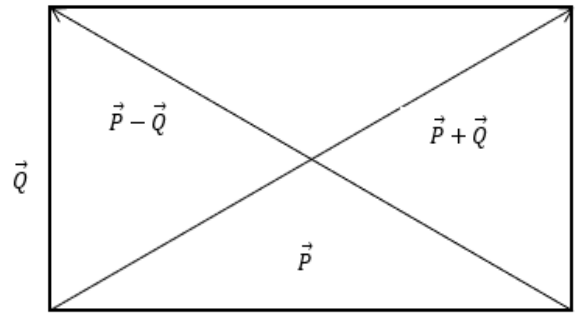
Figure 3

Constructing Frame of Mats Applying the Concept of Vector Geometry



The mathematical thinking and methods are quite different in different cultures (Gerdes, 2005). The mathematical ideas hidden in the process of constructing the frame to weave a mat in the rural community in Nepal is mostly equivalent to the methods that the Mozambican peasantry used methods of constructing the rectangular bases of houses (Gerdes, 1999). Further, Gerdes (1997) explored that the construction techniques of the house builders facilitate to formulate the rectangle axiom. From the observation of the different process of mat weaving, it was found that it includes a lot of mathematical ideas in the mat weaving activities. It is argued that it is possible to use indigenous mat weaving in the teaching and learning of mathematics at different levels from primary to a higher level.

The knowledge involved in the above methods for the construction of the rectangular form of the net of the mat weaving can be linked with vector geometry. Vector is an important and fundamental concept of modern mathematics. It is a useful tool to communicate different areas of mathematics like algebra, geometry, trigonometry and calculus. The knowledge involved in the methods for the construction of the rectangular frame for weaving a mat can be related deeply to vector geometry. In vector geometry, for two vectors $\vec{P}$ and $\vec{Q}$, $|\vec{P}+\vec{Q}| = |\vec{P}-\vec{Q}|$ if and only if $\vec{P}$ is perpendicular to $\vec{Q}$.



It is easy to prove this proposition, $|\vec{P}+\vec{Q}| = |\vec{P}-\vec{Q}|$

$\Leftrightarrow(\vec{P}+\vec{Q})^2=(\vec{P}-\vec{Q})^2$

$\Leftrightarrow\vec{P}^2+2\vec{P}\vec{Q}+\vec{Q}^2=\vec{P}^2-2\vec{P}\vec{Q}+\vec{Q}^2$

$\Leftrightarrow 4\,\vec{P}\vec{Q}=0$

This gives $\vec{P}$ is perpendicular to $\vec{Q}$.

It is equally applicable to the vectors $|\vec{R}| = |\vec{S}|$ if and only if $|\vec{R}-\vec{S}|$is perpendicular to $|\vec{R}+\vec{S}|$.

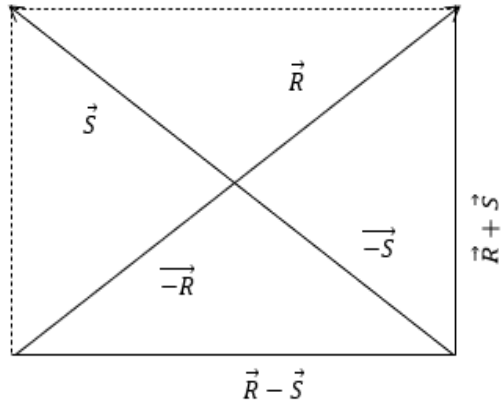
It is easily proved,

for $|\vec{R}| = |\vec{S}| \Leftrightarrow (\vec{R})^2 = (\vec{S})^2$

$\Leftrightarrow(\vec{R})^2-(\vec{S})^2=0$

$\Leftrightarrow(\vec{R}+\vec{S})(\vec{R}-\vec{S})=0$

This gives, $(\vec{R}+\vec{S})$ is perpendicular to $(\vec{R}-\vec{S})$.



In a cultural village of Nepal, a rectangular form of sitting or sleeping mat may be rolled up when it is not in use. Some people use sleeping mats as a larder for the purpose of reserve paddy. It then takes approximately the form of a cylinder. From the observation of the situations, this cultural experience provides an opportunity for students to obtain an idea of the calculation of the curved surface area, the total surface area, and the volume of a cylinder. The finished product is analysed to assess the embedded mathematical ideas in the mat and other cultural artefacts. We have a mat ABCD of length L and breadth H. Let us transform the mat ABCD into a cylinder by rolling up such that AC and BD are just in contact.

Figure 4

Rolled up Mats that can Provide Ideas to Calculate Area and Volume of Curved Surfaces



Here, Area of initial mat ABCD = Surface area of the cylinder = L. H
It is evident that the circumference of the base of cylinder (C) = L

This implies that $2\pi R = L$ gives $R = \frac{L}{2\pi}$

Let A be the area of the cross-section area of the circular cylinder, $A = \pi(\frac{L}{2\pi})^2$

Also, $V = A \times H = \frac{L^2}{4\pi} \times H = \left(\frac{L}{2\pi}\right)^2 \pi . H$. It gives, $V = \pi R^2 H$

Connecting Cultural Practices and School Mathematics

The cultural artefacts and activities possess lots of mathematical ideas. It is argued that it is possible to use indigenous mat weaving in the teaching and learning of mathematics at different levels of education. How does weaving, a cultural activity, help students in the learning process of some concepts of school geometry, was one of the objectives of this study. Weaving is a collaborative activity, which requires teamwork, but mostly it is concerned with the female adults of a family. Still, in the process of construction of the frame for mat weaving, support of other family members is needed. Most of the children engage and participate in this collaborative work. However, the mathematical ideas embedded in the process are largely hidden for these people. Regarding the mathematical ideas they possess in the process of frame construction, I recorded a conversation of teacher participant with his students:

Teacher: Has someone assisted his/ her mother in the process of construction of frame of mat?
Students: Yes Sir, we have.
Teacher: S1, how many times have you helped your mother?
S1: My sister helps her most of the time, I am novice sir!
Teacher: So could you find any geometrical ideas in that process?
S1: Hummm…
Teacher: And S2, how many times have you participated in it?
S2: Sir, I am used to it!
Teacher: Okay, could you observe any geometrical concept in the process?
S2: Hummm… I don't have much idea sir!

Both the students did not utter a single word regarding geometrical ideas embedded in the process though they practise them implicitly. Various study found that out-of-school knowledge familiar to the students are the sources for the teaching and learning of school mathematics. However, it was found that the making of connection between two conceptual domains is difficult. The teacher participant also agreed that the cultural artefacts and daily activities of the students are useful for the teaching and learning of school mathematics.

The incorporation of weaving activities in the process of teaching and learning enhance mathematical understanding of the students. The teacher, in his classroom, connected this concept by measuring the dimensions of the mat and rolling it to conceptualize the concepts of curve surface area, total surface area and volume of the cylinder formed. Then I conducted a post-class interview with the students. I asked the students how they felt about the teaching with an activity

based pedagogy. Regarding the effectiveness of introducing cultural activities in mathematics classroom, one of the student participants said, "I have learnt most of the mathematical concepts through rote and memorization just with an aim to solve problems and score good marks without any level of understanding. Now, the abstract concepts and ideas of curve surface area, total surface area and volume of a cylinder was visualized easily through these activities". From the interaction of my student participants, I came to know that, the students' everyday activities and experience play a vital role in the development of mathematical concepts. One of the student participants replied, "Before the use of this teaching model, we were just made to memorize the formula for purpose of solving common problems. Later, when this model was taken in action for teaching, we could easily visualize the abstract concepts and visualize it as a mathematical object".

Another student said, "After this class, I was surprised to know that mathematics could even be linked with the cultural activities that we were performing just for a household job. Now, I think that everything that we study can be linked with the cultural activities making even these boring classes interesting. This lecture really proves it."

The use of cultural artefacts and everyday activities of learners in classroom teaching seems to be really appealing and the outcome of the understanding as per the students was quite appreciable.

Conclusions

Weaving is one of the common cultural activities in different rural communities in Nepal. The weaving of textiles, sitting mat, sleeping mat, basket and other stuffs, reflect the cultural values and identities. The various mathematical ideas and thinking are inherited in the process of the construction of the mats. It was observed that the mat weaver exhibited sophisticated geometrical ideas in the process of construction of the net for the mat. It is argued that it is possible to use indigenous mat weaving in the teaching and learning of mathematics at different levels of schooling. The incorporation of ethnomathematical ideas of mat weavers with school mathematics enhances the elaborate meaningful connections between the mathematical ideas of two different world (home and school) where the children live and learn simultaneously. The teaching and learning of school mathematics can be enriched if the concepts taught are based on students' experiences and practices.

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