EMBODIMENT OF GEOMETRY IN TRADITIONAL NEWARI ART: AN ETHNOGRAPHIC INQUIRY

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DECLARATION

I hereby declare that this dissertation has not been submitted earlier for the candidature for any other degree.

_____ July 31, 2018

Manoj Shrestha

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DEDICATION

This work is dedicated…

To all Paubha Artists, teachers, mathematics educators as well as my beloved family members.

Master of Education in Mathematics Education dissertation of *Manoj Shrestha* entitled *Embodiment of Geometry in Traditional Newari Art: An Ethnographic Inquiry* was presented at School of Education, Kathmandu University on July 31, 2018.

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I understand and agree that my dissertation will become a part of the permanent collection of the Kathmandu University Library. My signature below authorizes the release of my dissertation to any reader upon request for scholarly purposes.

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ABSTRACT

An abstract of the dissertation of *Manoj Shrestha* for the Degree of *Master in Mathematics Education* presented at School of Education, Kathmandu University on July 31, 2018.

Title: *Embodiment of Geometry in Traditional Newari Art: An Ethnographic Inquiry*

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"What if students encounter the same thing in mathematics classroom that they have been seeing in their home, society or day to day practices?" I believe it is unfortunate to see the exclusion of students' cultural aspects in mathematics classroom as in context of Nepal, the students belongs to diverse cultural and ethnic groups. Hence I felt the necessity to conduct a research study on cultural integration in mathematics classroom to uncover its potential in enhancing mathematics learning. I chose to conduct research on Newari cultural to which I belong with my major research questions; "How geometry is manifested in traditional Newari art?" and "How can we incorporate 'ethno-geometry' in basic level school mathematics teaching and learning approach?"

I chose geometrical practices in Newari traditional art as major subject to explore in my research study. Hence, the whole research study was guided by qualitative ethnographic research design. With remarkable time invested in observations and interviews I encountered many geometrical practices that are distinct from our mainstream pedagogies but yet very simple. On the basis of various

literatures that I have reviewed in my research study I can assertively say that there are some positive changes that can expected by incorporation of traditional approaches in geometry teaching and learning. Plenty of arguments presented by my research participants supporting cultural incorporation in mathematics teaching approaches encouraged me to conduct further research on other sector like use Newari artifacts in teaching and learning mathematics.

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Manoj Shrestha, Degree Candidate

ABBREVIATIONS

CBS	Central Bureau of Statistics
CDC	Curriculum Development Committee
CPBL	Cultural Project Based Learning
CRP	Culturally Relevant Pedagogy
KU	Kathmandu University
M. Ed	Master in Education
M. Sc.	Master in Science
MOE	Ministry of Education
PBL	Project Based Learning
Ph. D	Doctor in Philosophy
SLC	School Leaving Certificate

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CHAPTER I

INTRODUCTION

Chapter Overview

I believe the pursuit for wide knowledge in mathematics is ultimately for the practical purposes. In this chapter, I have tried to put forward my beliefs in understanding vital roles of mathematics in reforming society. For this, it is crucial for us to have idea about the cultural and social nature of mathematics. I have tried to study about the Newari Culture and search the various geometrical approaches embraced by the traditional Newari Art. Besides this, I have emphasized on searching for the possible ways to incorporate those geometrical practices and ideas in school curriculum to get the optimum performance in learning mathematics. In addition, this chapter aims to present brief introduction about the Newar community.

Background of the Study

I completed my school level education from one of the private schools in my community. The school was located in typical Newar community where more than 90% of my friends in my classroom were from the Newar community. Even most of the teachers used to be from the same community. But still I hardly remember my teachers bringing any cultural aspects in mathematics classroom. The memorization of the topics without knowing meaning or process was major practices which we used to do most of the time. So, we often faced many difficulties in learning mathematics. We used to speak in Newari language and saw many teachers speaking in Newari language to each other but there was not any use of Newari language inside the classroom while explaining mathematical concepts. In another word, there was not

any space for cultural incorporation during teaching and learning mathematics. The way mathematics was taught was almost similar after completing my SLC examination too. I found that we were mostly guided to solve the given problem just like we did before the SLC examination.

The way we were taught mathematics was as the theoretical discipline about the patterns and relationships. Today's mathematics has been developed through years of devotion of numerous minds belonging from different cultural background across the world. Each culture had contributed in the evolution of mathematics hoping to meet their fundamental necessities of their daily life. In this sense, we cannot deny the fact that the source of mathematics is from every corner of the world although the worldview of mathematics today has come mostly from the Western European Culture which describes mathematics as a body of pure knowledge (Luitel, 2013). We too are having the mathematics curriculum in our classroom which is influenced by the mathematics introduced by the British during their colonial time in India although India had their own mathematical approaches and knowledge and masterminds. The influence of British mathematics in Nepal seems the local and its cultural mathematics is deprived of being included in school curriculum.

I believe that there should be adequate space for the multiple cultures that we have in our society in our classroom as well as school curriculum. There is no point in arguing that Nepal is very rich in different culture. But we are failing to utilize our cultural variation in mathematics. Cultural diversity has been an inseparable part of the nations' economy since it is contributing a lot in boosting tourism sector inside the country. I feel it is crucial to explore embedded mathematical practices by incorporating culture, approaches, daily activities and also different cultural artifacts. I think by relating the cultural practices and artifacts with the content of the

mathematics in their schools can attract students towards learning mathematics. Introduction of Ethnomathematics can enhance the students' learning and knowledge by taking their socio-cultural activities in account (Rosa, & Orey, 2015). I could sense possibility of incorporating the diverse traditional mathematics approaches of the students from the multiple cultural backgrounds is highly appreciable to set the learning environment of mathematics in the classroom. Contextualization in teaching mathematics escaping from the conventional way of teaching by linking the pedagogy with the local context can be aimed from this (Jablonka, & Gellert 2007). I think it can motivate the students to know the im/pure nature of mathematics (Luitel, 2013) and the relevancy of the culture and mathematics they are learning in the classroom. I, myself had an experience of having fun in learning geometry while my teacher used to present an example of a temple or an stupa while explaining about various geometrical shapes. To sum up, there is possibility to develop the feeling of respect to other cultures by taking such types of real based example to enhance their mathematical understanding. The learners get an opportunity to feel how their cultural practices and artifacts are vital historically as well as for perceiving geometrical knowledge. They could easily explore the mathematical ideas in the cultural diversity and implanted knowledge of mathematics in those cultural practices (D'Ambrosio, 2001). There is an inseparable role of the teachers to bring existing ethnical and traditional knowledge in the classroom to empower students' learning through socio-cultural activities.

For this purpose, I felt the important of the Ethnomathematics where we could learn mathematics in better and easier way. I have observed my culture very closely and seen the possibility of teaching mathematics in a relaxed way. Historically, my community belongs to Kathmandu Valley where my ancestor has built many temples,

Chaityas and other important structures like stone taps. And some of these monuments of Kathmandu Valley have been enlisted in UNESCOs World Heritage Sites which is flourishing tourism in the country and uplifted nations' economic status as well as also increased nations fame to the higher level. There is no doubt that for the creation of such master pieces in art and architecture which lure thousands of tourists yearly, they need to have wide knowledge of mathematics, mainly concepts in geometry. I tried to focus on the long-established Newari Art trying to explore various mathematical approaches; especially Geometrical ideas embodied in those artifacts. The structures they have built, the traditional paintings they have created is exceptional symmetry and this is the point which made me think about the incorporation of those ideas and their perceptions towards mathematics in school level mathematics. Furthermore, being a person from the Newar community, I see the ethno-mathematical part in every social and cultural activities performed by the Newari people. Besides art and architecture, the cuisine in Newar community needs the concept of proportion. Even in the traditional farming system, they can maintain symmetry and do precise partitions in their field manually. They possess wide knowledge about the astrological part as well and some can even foretell the future after going through long mathematical process and calculations.

The Newars are the creators of most examples of art and architecture in Nepal. Many stone inscriptions written in Newari scripts can be found in temples and chaityas describing about its date of construction and the name of kings or any other person who built it. Kathmandu Valley which is regarded as the core area for Newar settlement from early period of time is filled with innumerable ancient monuments which are decorated with various textures and arts. Many traditional Newari drawing can be also seen on the doors of houses and during a range of rituals. Traditional

Newar art is basically religious art. Newar devotional paubha painting is world-renowned exquisite beauty. The extraordinary precision in drawing various geometrical shapes and symmetry can be noticed in their paintings. Those geometrical ideas and approaches are worth studying for the development of mathematics teaching and learning.

Being an art enthusiast Newari Paubha drawings have always attracted me. It was the day back in 2015; I met my old friend Mr. Sundar Shrestha when the mathematical aspects of the Paubha drawing struck my mind for the first time. He has been doing traditional Paubha drawings for almost a decade (from personal conversation, April, 2017). The way he drew various geometrical shapes was quiet fascinating. For instance, to draw a straight line he holds straight rope which was soaked in color powder and tapped it on the canvas. Similarly, He demonstrated how local materials can be used in drawing geometrical shapes mostly circles, squares, rectangle and triangles while drawing Paubha. I have tried to explain the procedure of drawing those shapes in my research. I felt these approaches can make students think beyond compass, scales and provide effective alternatives for using conventional ways of teaching various geometrical shapes in mathematics classroom.

Rationale of Study

There is significant role of Ethno-mathematics more than uplifting the standard of teaching and learning methods. It can play very important role to promote our cultural and contextualized mathematics teaching in our classroom. My study aims to raise the feeling of respect in students towards other ethnic and cultural groups and appreciate the cultural and traditional diversity that our society possesses. I strongly believe, it can contribute remarkably to uplift or empowering the various cultural groups that has been remaining as the dominant group from long period the

time (DiAngelo, 2012). Further, it can also help in making the students in the class to think critically about the dominant or the marginalized groups inside their classroom (D'Ambrosio, 2001). Through the study, I tried to explain how cultural and ethnical approaches of learning mathematics and their different types of day to day materials can contribute to learn mathematics in a fun way. Hence, my study tries to recognize that ethno-knowledge which is still embedded in the society. I believe this study would bring a crucial insight for both teachers and students about the ethno-mathematics and present the ideas about how the mathematical knowledge can be brought in practice to solve daily problems (Rosa & Orey, 2010).

In the present context where mathematics is merely regarded as the algorithmic solving of the abstract mathematical problems, my research aimed to bring students out of their classes and be familiar with their own cultural nature and how they can connect it in mathematics. By this I believe emancipation from Western Modern Worldview (WMW) of mathematics and widely considered absolute nature of mathematics can be expected from my study by successful introduction of ethno-mathematics in school education. It assists in setting the classroom environment in which all ethnic groups are held together giving emphasis to all of them equally (Eglash, 1997). Furthermore, by adopting the ways of pursuing mathematics of own selves and friends, students are very likely to develop the notion of collaborative learning in the classroom which can further enhance the learning process.

Problem Statement

Being a mathematics teacher and an M.Ed. student of the Kathmandu University (KU), I felt that there is an immediate requirement of reform in teaching and learning mathematics. As a mathematics learner and a teacher I think teaching mathematics in classroom seems to be more like The Training; training to solve the

given mathematical problem in mere mathematical algorithm. Teaching and learning mathematics is more focused on achieving higher grades in an examination rather than perceiving fruitful education which should be realistic. Both students and teachers are facing numerous problems in mathematics classroom. The problems that arise during teaching and learning mathematics are related to both pedagogical and of proper use material. In other word, I think the mathematics teaching and learning is guided by de-contextualized pedagogies. Regarding both problems I felt the inadequate of integration of local knowledge in mathematics classroom. Teachers are often bounded by the curriculum and students are circumscribed to get the knowledge as prescribed by the curriculum.

The mathematics that we have currently in our schools is greatly influenced by the Western European Culture and it needs to be linked with the local and cultural activities of the students inside the classroom (Luitel & Taylor, 2007). Traditional Newari art can be studied to explore the masked geometrical knowledge and possess huge potential to be linked with classroom pedagogies. The ethno-geometry concealed in traditional Newari art which they have been drawing as a part of their culture, can help the students to extend mathematical knowledge beyond the four walls of classroom. Hence, by this, I believe incorporation of enthnomathematics can contribute in dropping the poor performance of the students in the classroom as well as examinations. During my teaching and learning period, I found that there is comparatively low achievement of the students in mathematics than in other subjects. This might be due to the presentation of the mathematics as a pure and abstract subject. My research can act as the motivational factor for the students in learning geometry with compassion (Zaslavsky, 1991). It suggests that there is an urgent need

of endorsement of those cultural activities to address the cultural nature of mathematics.

Another unavoidable aspect of learning mathematics in classroom is to develop the skill of interaction among the students for enhancing their learning; where present pedagogical approaches are being failed. There is often less participation of the students in leaning mathematics which can be mended by incorporating cultural practices in mathematics classroom. Cultural practices in drawing Paubha demand abundant knowledge about the geometry. I have faith that traditional Newari art comprises of various geometrical knowledge and practices can make mathematics more fun and enjoy the every single task.

Likewise, there is an issue of use of local language to be addressed. As I have mentioned before, there were more than 90% students in the classroom who belong to the Newar community when I was a student. I believe if there was wise use of the mother tongue in some extent, it could have remarkable effect in learning mathematics. Obviously, it is a challenging task to do but I am sure with proper planning and the authority given to the teachers to conduct the classroom integrating some local language, it would not take much time to improve students' knowledge in geometry.

Purpose of Study

The main purpose of the study is to explore the ethno-mathematical knowledge and practices in the areas of geometry in Newari Art and to investigate the possible ways of incorporating them in lower secondary level school mathematics teaching and learning approach.

Research Questions

My research has following principal research questions, this research attempts to explore following research questions:

1. How geometry is manifested in traditional Newari art?
2. How can we incorporate "ethno-geometry" in the basic level school mathematics teaching and learning approach?

Delimitations of the Study

My main intension of my research study was to explore the ethno-geometry practiced by the Newars to study about their traditional Newari art; Paubha. I have tried to explore the ethno-mathematical knowledge of the Newar community by consulting with the Newar scholars who still dwells in this town. Newars can be found inhabited in the places like Banepa, Panauti, Sankhu, Dolkha and Nuwakot but Kathmandu Valley can be taken as the core place for Newaricommunity. Although it seems like the minority in Kathmandu Valley due to in-migration of large number of people and out-migration of many Newari outside the valley, I can still notice the valley filled with abundant structures representing its unique art and architecture. Hence I have selected Kathmandu Valley as my field of study. The main focus of my study has been based on geometrical practices as mentioned above and the possible incorporating ways in teaching and learning of lower secondary school mathematics.

Chapter Summary

In this chapter, I intended to put forward my beliefs on cultural nature of mathematics. In the present context, where we can often find the beliefs of treating mathematics as culture free subjects, I found it is crucial to bring the learners social and traditional background inside the mathematics classroom for fruitful learning. To provide proper insight on that I have tried to bring my own past experiences as both

mathematics student and a teacher. Along with the brief introduction of the Newar community, I have tried to present the idea that Newar people are loaded with cultural art and architecture and we can witness abundant geometrical knowledge embedded in their traditional Paubha drawings. Besides this, I tried to explain that there is immense necessity of exploration of mathematical knowledge hidden in various cultural practices. For that, I chose my research questions accordingly to conduct my research on systematic way.

CHAPTER II

LITERATURE REVIEW

Chapter Overview

This chapter includes brief review of the various literatures related with the Ethno-education, Ethno-mathematics and cultural nature of mathematics. In other word, it includes a critical description of literatures relevant to my research. This will provide me with a handy guide and will act as a stepping stone to my study. These reviews are concerned with the incorporation of Ethno-mathematics in school curriculum. Similarly different theories related and supporting the ideas in the research have been discussed in this chapter.

Thematic Review

The major themes or ideas of the research have been discussed under this topic. Since of my research topic is " Cognitive embodiment of geometry in traditional Newari art: An ethnographic inquiry", the main theme of my research has been the mathematics in Newari culture. In another word, Ethnomathematics embedded in traditional Newari art has been another important topic to discuss. According to D'Ambrosio (1985), "It is the mathematics which is practiced among indentifiable cultural groups" (p. 18). In this research, I have focused on cultural practices of the Newar community. In this sense, we can say that the mathematics is not culture free. Cultural nature of mathematics will be the next theme of the research. I am looking forward to explore the ways of incorporation of cultural aspects of mathematics in teaching and learning mathematics in classroom. Similarly, other

important ideas that will be discussed in this chapter are about culturally relevant mathematics pedagogy and the brief introduction about the Newari community.

Ethnomathematics

Ethnomathematics is presented by a Brazillian mathematician Ubiratan D'Ambrosio(1985) as intersections of culture, historical traditions, socio-cultural roots, and mathematics. It tries to deny that mathematics is independent of culture. For the productive teaching and learning, a teacher must know his students well; their true potentiality and weakness. It can be only achieved by knowing about their cultural background (Delpit, 2006). Ethnomathematics focuses on the contextualization of mathematics learning. It can make teaching and learning mathematics culturally relevant by introducing cultural practices and various cultural artifacts in mathematics classroom (Torres-Velasquez & Lobo, 2004). The resemblance of the cultural diversity in the classroom should be noticeable throughout the teaching and learning process.

As I belong to the Newari community which is considered to be an indigenous group of Nepal, the exploration of ethno-geometry in traditional Newari art was my prime concern. Through this, we can develop the notion of respect to other cultural groups in the process of teaching and learning mathematics as it is highly unlike that all the students in the classroom belongs to the same cultural or ethnic group. Further, "Culturally relevant mathematics curriculum should focus on the role of mathematics in a socio-cultural context that involves the ideas and concepts associated with ethnomathematics, using an ethnomathematical perspective for solving contextualized problems" (Rosa & Orey, 2008, p. 34). According to Zeichner (1996), teachers should be more concerned in implementing the concept of the principle of cultural congruence. Many research studies have been conducted on cultural congruence

respecting its essentiality in teaching and learning mathematics. "The overall hypothesis in research on cultural congruence is that students of diverse backgrounds often do poorly in school because of a mismatch between the culture of the school and culture of the home. Students have less opportunity to learn when school lessons and other activities are conducted, or socially organized, in a manner inconsistent with the values and norms of their home. A related hypothesis is that students of diverse backgrounds will have better learning opportunities if classroom instruction is conducted in manner congruent with the culture of the home"(Kathryn &Kawakami, 1994). Teachers should have knowledge of and respect for the various cultural traditions and languages of students in their classrooms. In so doing, they should develop a clear sense of their own ethnic and cultural identities to be able to understand and appreciate those of their students in order to perceive mathematics as socially and culturally constructed disciplines (Banks, 1991; Lee, 1999).

A classroom includes the students from various cultural backgrounds. An efficient introduction ethno-mathematics in classroom enables students not only to value the culture they belong but also respect other cultural groups. By bringing cultural artifacts and approaches of learning mathematics in classroom, a teacher can ensure the preservation of cultural dignity of the students and make them aware about their abilities to use local technologies in successful teaching and learning mathematics. Since ethno-mathematics does not only talks about mere reading, writing and solving mathematical problems it has more to offer for the students in teaching and learning mathematics (D'Ambrosio, 2001). I believe it can make both teachers and students able to avoid the common misunderstanding about relationship between mathematics and culture. During, my teaching experience, I felt like teachers and students equally often find themselves bounded within the curriculum and

classroom. Another unavoidable reason for being mathematics classroom boring and unproductive is the obligation of completion of the course on time. Students are not given chances to experience mathematics outside the classroom (Gerdes 1990; Ascher, 1991). I believe ethnomathematics can contribute addressing this problem and enhance teaching and learning mathematics.

Cultural Nature of Mathematics

Previously, mathematics was regarded as the universal, it is culture free. This perspective in mathematics has been challenged. The question is rising, "Is mathematics actually universal, objective and culturally neutral?" According to Bishop, Hart, Lerman, and Nunes (1993, p.1), "There is no sense in regarding mathematics learning as abstract and culture free" because the learning process cannot be abstract and context free, that is, learning cannot be free of societal influence. The teachers' view of mathematics is transmitted to the students in their instructions, and this fact helps to shape students' views about the nature of mathematics. As a mathematics student, I was taught to construct a square during my school days which now I know is guided by Western Modern Worldview (WMW). At the same time, I can see many Newar artists drawing square in their traditional paintings as well. The only difference is in the procedure and they don't call it a 'Square'. Hence, I believe dialectics in the concept of the mathematic describes mathematics as a body of im/pure knowledge (Luitel, 2013).Existence of students from multicultural background inside the classroom should be properly accepted. I believe by bringing students' cultural we are valuing the resources they bring to inside the classroom. Proper environment for mathematics learning can be set by carrying out inter-cultural comparison within the classroom.

The notion of mathematics being the body of impure knowledge can be associated with the cultural aspect of the mathematics since it includes local and cultural activities of the specific cultural group. Cultural nature of mathematics can be introduced in the mathematics classroom by which students can acquire real mathematic knowledge remaining under the knowledge they get from their day to day practices (Prediger, 2007). Intercultural exchange of knowledge in the classroom bring the learners outside of their classroom and make them able to see the mathematics in uncommon way; the way through which they can emancipate themselves to sensible mathematical learning (Jablonka, 2003). Mathematics is regarded as the practices developed in different cultural groups from different corners of the globe. In this perspective, if mathematics is considered as a cultural construct, then it is a product of cultural development (Rosa & Orey, 2007). All these things suggest that the culture and mathematics can be regarded as inseparable parts in mathematics education.

Culture means peoples' language, place, traditions, and ways of organizing, interpreting, conceptualizing, and giving meaning to physical and social worlds (Asher, 1991). There are mathematical ideas and knowledge dwelling in those practices that need to be explored. The potential of mathematical ideas and knowledge in enhancing geometrical concepts in students must be examined. It is crucial to explore how those mathematical concepts are being used. Cultural nature of mathematics enables students to learn non-western mathematical practices unlike the one that is in front of them as a course or curriculum while learning mathematics. Besides this, we can say that cultural nature of mathematics focuses on emphasizing cultural realities and mathematical approaches while taking proper consideration and appreciating formal mathematics learning inside the classroom.

Culturally Relevant Pedagogy

Nepalese classroom is comprised of cultural diversity. Teacher in classroom has to carry out his/her pedagogical approaches which must be equally convincing for all those students who belong to various cultural backgrounds. Most of the time, it is really tough work for a teacher to teach mathematics effectively who might be from dissimilar cultural background. So, frequent discussion with the students about their culture can truly advance the students' learning (Ladson-Billings, 2001). It means conventional pedagogy in mathematics classroom should now provide a space for Culturally Relevant Pedagogy. Culturally relevant pedagogy "can be defined as using cultural knowledge, prior experiences, frames of reference, and performance styles of ethnically diverse students to make learning encounters more relevant and effective for them" (Rosa & Orey, 2013, as cited in Gay, 2000, p. 29). CRP in mathematics classroom mainly intends to be the bridge between local and formal teaching and learning mathematics.

CRP can assist in linking culture and school pedagogy. It can play vital role in mathematics classroom but proper interest must be taken by the facilitator. Teachers must be able to connect culture with the mathematics learning but at the same time he/she must be careful about not being culturally biased. S/he should have proper insight of his own cultural background. "Culturally relevant teachers utilize students' culture as a vehicle for learning" (Ladson-Billings, 2001, p.161). CRP can further help in academic excellence in mathematics teaching and learning. Through the proper integration of CRP in classroom, teachers can develop numerous academic skills and competencies. Students are highly encouraged to present their local knowledge; especially learnt from their home in front of the class and carry on further discussion on it. CRP emphasizes on the overall academic excellence of the entire

class through the introduction of any specific cultural practices in the mathematics classroom.

Similarly, CRP is an essential factor to develop awareness in the teachers about their own culture and others. At the same time, it helps teachers to understand his students well. To conduct CRP inside the classroom more efficiently there may be the requirement of visiting students' family and locality to have proper understanding about their cultural background. It creates an opportunity for the teachers to have interaction with the parents and other community members. Hence, CRP can enable them to face the challenges in the mathematics classroom and can assists in lowering the poor performances by their students significantly (Banks, 2004).CRP demand proper and strong communication between the teachers and students and also among the students themselves. Mathematics educators nowadays, seem more inclined towards CRP due to same reason. They are being more conscious about the exploration of different natures of mathematics. "One of the major shifts in thinking in relation to the teaching and learning of mathematics in recent years has been with respect to the adoption of differing views of the nature of mathematics as a discipline"(Nickson, 1994, p.10). CRP can ensure the active participation of the students in teaching and learning process. It can help students in constructing the knowledge based on the cultural diversity they have in their classes. At the same time, through CRP, both teachers and students can develop their required materials with local knowledge which can enrich their thoughtfulness.

Theoretical Review

The theories are the bases on which the ideas can be presented. They will provide the support to pave the way to conduct my research more efficiently.

Habermasian Theory on Human Interest

Also known as 'knowledge-constitutive interests', Jurgen Habermas' theory of human interest can be taken as the most influential theory for the cognitive learning process. This theory advocates that knowledge is not discovered but is constructed. The three human interest by Habermas are Technical Interest, Practical Interest and Emancipatory Interest.

Technical Interest. The technical interest is guided by empirical-analytic knowledge. According to this, the human is more guided towards the fundamental human interest of surviving and gaining knowledge. Hence, they are oriented towards controlling and manipulating the environment. This concept drives people to have focus on the product of their knowledge and practices. Habermas believes that action in the technical interest implies a need to control events rather than making meaning is fundamental to understanding why the positivistic view of knowledge as actual, certain, exact, reliable, valid, and verifiable might be unsustainable in the social world (Grundy, 1987b; Guba & Lincoln, 1989; Lincoln & Guba, 2000). In order to achieve the expected product, the curriculum is designed as the curriculum as product. The technical interest is grounded on experience and observation. All the activities are focused on the product and the system of education is more structured. Here, the main focus will be whether the Enthomathematics that has been practiced in the classroom is able to provide the students with necessary help for getting knowledge and surviving in more appropriate way or not.

Practical Interest. The practical Interest is more concerned with the construction of knowledge through interaction. The knowledge is guided by historical-hermeneutic science where there is consensual understanding. It accepts the historical knowledge but do not take the knowledge as granted. The center of attention is to critically analyze the historical knowledge and then take them in action in wise way. My research in the same will try to find the possible ways to incorporate different geometrical knowledge in Newari practices in school curriculum for its proper use. The practical interest intends to understand the environment so that one is able to interact with it. I believe the proper setting of the classroom in which the local practices of the students are respected and introduced in the mathematics classroom in regular basis can boost their inclination towards mathematics learning. At the same time, it is highly likely to encounter the new mathematical practices through interaction about the students' cultural background which has been the major objective of my research study. I believe Ethnomathmatics in the classroom will contribute in creating an ideal environment for proper interaction which is more likely to help the students to construct knowledge through consensual understanding.

Emancipatory Interest. Emancipation for Habermas means, "independence from all that is outside the individual " and is a state of autonomy rather than libertinism. According to this interest, knowledge is based on critical theory where learning is done through critical self-awareness and self-reflection. Knowledge is gained by self-emancipation through reflection leading to a transformed consciousness. With the idea of ethno-mathematics in school curricula, the possible incorporation of geometrical knowledge in Newari culture may provide students with an opportunity to see beyond the traditional approaches of learning mathematics. I think through ethno-mathematics students can be motivated to construct knowledge

on the basis of their prior knowledge perceived via various day to day activities and cultural practices. They are encouraged to think out of the box; think and observe their local knowledge from different perspective coming out of their classroom. It represents freedom from the coercion of the artificial world of the technical interest, which has colonized life in the social world (Starratt, 1996; Young, 1989).They will be provided an authority to choose their own way in which they may feel easier to learn mathematics, especially geometry.

Social Learning Theory

Lev Vygotsky believed that the life long process of development was dependent of social interaction and that social learning actually leads to cognitive development. It means social interaction is one of the inseparable parts of learning. Children learn more through interactions, social interactions on the basis of their prior knowledge. But the education system that we have currently bound them to limit their interaction with the friends and stick with the course provided. I think the classroom with the presence of children from diverse community and culture can be transformed into an effective learning place. It can be done by incorporating the cultural practices in teaching and learning approaches in mathematics classroom. That means there is a need of adopting ethnoeducation in classroom, "Ethnomathematics as the arts or techniques developed by different cultures to explain, to understand, to cope with their environment (D' Ambrosio, 1994, p. 1184)" The students must be given adequate chances to get familiar with those cultural approaches of practicing mathematics from different cultural communities. They must be properly guided and encouraged to manipulate and relate the various mathematical ideas embedded in cultural practices distinct from their own as well. "Through their capacity to manipulate symbols and to engage in reflective thought, people can generate novel

ideas and innovative actions that transcend their past experiences" (Bandura, 1986, p. 1182). There is a crucial role of the teachers in developing this quality among their students. It can contribute to create bridge between culture and curriculum for making the learning process more effective.

Empirical Review

Empirical Review is crucial to know about the researchers' position in the research. It offers the researcher with the vital information about the previous researches which had been conducted for the same purpose, if not for the same purpose. Rai (2016) has conducted research on 'Mathematical Practices in Rai Community and Pedagogical Use'. The research conducted on the Rai community has presented their cultural artifacts as mathematics learning materials in classroom. Lama (2013) has conducted the research on 'Geometrical knowledge in socio-cultural activities of Tamang community and its place in primary levels curriculum development'. The research has been able to present the cultural nature of mathematics. Further, with the research conducted in Tamang community, it has tried to put forward the ideas that mathematics is being practiced in every culture and its possible incorporation in school curriculum can make the learning process more enjoyable and effective. It means, the ethno mathematical practices in various cultural aspects have profound potentiality of implications mathematics education.

The research conducted by Gautam (2004) on "The concept of geometry in Tharu culture an ethno mathematical perspective of Tharu in Chitwan" has emphasized on the same theme. Kandel (2005) has done a study on, "The basic mathematical concepts and process of Chepang Community". In his study he concludes that; the numeration system in Chepang community is base 20. As I belong to Newari community which is culturally rich, made me privileged to conduct

research on my own community. This motivates me to conduct the research on exploring geometrical practices in Newari Culture regarding its potential to uplift the geometrical ideas among the students.

Research Gap

The above research studies show that many studies have been conducted in different cultural and ethnic groups in Nepal. There is indeed abundant mathematical knowledge embedded in traditional and cultural practices of various cultural groups. But I was unable to find the research conducted in Newar community exploring geometrical practices in their day to day activities and cultural practices. Hence, I plan to conduct research on 'Geometrical practices in Newari Culture' and try to explore the ways for its possible incorporation in teaching and learning approaches to support the cultural nature of the mathematics.

Chapter Summary

In this chapter, I have presented culturally relevant pedagogy, cultural nature of mathematics and Ethnomathematics as major themes of my research. These are the most essential issues that needed to be discussed for my research study since these themes helped me to see mathematics as an abstract subject. In theoretical review section, I tried to bring various theories that can back up and provide strength to my research. In another words, I have tried to conduct my research on the basis of those theories. Similarly, Empirical review section of my research advocates that no research has been conducted previously on the similar topic. I believe the literature review in this section has provided me with necessary guidance and path to find my research goal.

CHAPTER III

RESEARCH METHODOLOY

Chapter Overview

In this chapter, the methodologies I have chosen for my research is discussed. Besides this, data collection tools and techniques of the research and the process of data analysis are also presented here. It further offer the information about the research site and research participants that I look forward to use in my research. It also includes quality standards of my research along with some ethical considerations that I plan to preserve as a researcher.

Research Methodology

The methodology of my research is qualitative research design. Since the aim of my research was to investigate different mathematical (geometrical) knowledge practiced in Newari community, ethnography best suits my research design. By investing quality amount of time in observing various practices and procedures adopted by the Newari Paubha artists I tried to explore the local ideas related to geometry teaching and learning. Similarly, I tried to look at their major strengths of bringing mathematical learning process in the mathematics classroom in its optimum level. I also tried my best to find out the possible demerits and limitations of bringing those ideas in teaching geometry in mathematics classroom. Ethnography, emerging from anthropology, and adopted by sociologists, is a qualitative methodology that lends itself to the study of the beliefs, social interactions, and behaviors of small societies, involving participation and observation over a period of time, and the interpretation of the data collected (Denzin and Lincoln,2011; Reeves, Kuper and

Hodges, 2008, 1991). My primary task was to expose the various approaches to acquire and use the geometrical knowledge by the Newari community in their traditional Paubha drawings. In other words, I have tried to seek the ways how geometrical knowledge is practiced in behaviors of Newari Culture. Along with the incorporation of those ideas in teaching and learning mathematics approaches, students will be provided with sufficient time to have interaction on those ideas. In present classroom, students assemble together from multicultural backgrounds, where they mostly love to construct the mathematical knowledge on the basis of those social interactions.

Research Participants and Sites

For my research, I have tried to study about the geometrical knowledge of people of Newari Culture. Since, Kathmandu valley is the center for Newari community, my study was conductedwithin the Kathmandu valley. My research participants were the painters of Newari Paubha; a sacred traditional art with illustration of various gods and goddess who shared all the required information and narrated the culture; its origin, current situation and its potentiality to contribute in mathematics teaching and learning. Likewise, I have tried to discuss about the Newari art and architecture with the experts and how they perceive geometrical knowledge. For that I have chosen four Paubha artists. Among them, three were renowned senior Paubha artists who have dedicated almost their entire life in drawing traditional newari paubha. They all are still working hard to uplift traditional paubha drawings till international level. Another research participant who is also my close friend has spent almost a decade in drawing Paubha. During my research study I got engaged in numerous discussions for hours with many other Paubha artists; both young and elder. In most of the cases the discussions were informal. The findings that I obtained from

all those other artists and my 4 research participants are almost same. Hence, I felt there is no need of going for other artists since my major research participants are the experts in present Paubha art field. As per my view, research is not only to seek the geometrical knowledge practiced in Newari Culture but also to explore the possible ways of its incorporation in school curriculum, I have spent an adequate time talking about the same thing with one of the curriculum designers as my another research participant. Similarly, I chose two mathematics teachers who have invested more than a decade in teaching mathematics in both lower secondary and secondary level to discuss about the present condition of mathematics classrooms and possibilities of the incorporation of geometrical knowledge practiced in various cultural groups of our society. Besides this, I had frequent discussion with many others teachers and some students to get some additional vital data for my research study.

Tools and Techniques

As my research is qualitative research and has ethnographic design, I believe *Observation* and *Interview* as effective tools and techniques for the data collection to conduct my research more effectively and strongly. To acquire the necessary information for my qualitative research, it is crucial to invest substantial amount of time with my research participants having prolonged discussion. Similarly, it is essential to have in-depth observation of what they did. Taking a proper field notes provided additional assist in receiving required information.

In-depth Interview

An important technique or tool to collect information in qualitative research design is an Interview. Interviews are intended to provide detailed information in any topic. To ensure this I have tried to conduct my research interview with semi structured questionnaires which provided plenty space to present their view openly

(Patton, 2002). Further, I have tried to bring participants' experiences in interview. I have worked immensely in making my questions short and understandable. I have spent more time having discussion with the various scholars of Newari cultural and traditional art. I chose 4 major paubha artists as my research participants. I spent many hours individually to talk about various geometrical ideas and approaches that they adopt for drawing. The information they provided were encouraging me to conduct my research study but in order to get additional information I visited numerous artists. Besides this, I visited one of my friends; who has been paubha artist since many decades and has been student of renowned paubha artists of Nepal more often. I am really grateful to him that he didn't hesitate to demonstrate traditional ways of drawing geometrical figures. I did video recording of all those demonstrations and taken major field notes. It was highly encouraging to get positive response of my research participants while introducing local knowledge in mathematics teaching and learning.

The interview with curriculum expert and designer and another research participant was mainly focused on the space provided by present mathematics curriculum in incorporation of traditional mathematical knowledge in teaching approach. I tried to get the necessary information by listening to the audio record of the interview and other field notes. Likewise, I had both formal interview and other informal discussion with mathematics teachers on the topic of my research study. The audio recording of those interviews was done to retrieve the essential information later on.

Interview with other educationist and cultural practitioners supplied me with vital data and information for my research. It was crucial to learn about their insight on the topic I researched which would be only possible by having prolonged

discussion with them (Boyce &Neale, 2006). Hence, being hopeful to obtain enough data for my research I visited Newari Paubha artist; specially my friend who has been my research participant for several times and had also carried out number of discussions with the mathematics teachers in different times for the same purpose.

Observation

To understand how the Newari people perceive geometrical knowledge, I needed to spend sufficient time in observing their daily activities and also traditional works of making historical artifacts and painting. By this I can observe the exercise of geometry in their professional works as well. Furthermore, at the same time, being a participant observer I had an opportunity to compare and contrast the approaches of acquiring mathematical knowledge in school and in society. "Unquestionably, observations represent a frequently used form of data collection, with the researcher able to assume different roles in the process" (Spradley, 1980; Creswell, 2012, p. 212). In-depth observation was carried out multiple times regarding the geometrical practices that the artists exercised during traditional Paubha drawing process. For this, after conducting an interview, I tried to observe whatever they have said in their work.

As, most of them were at the middle of their work, I requested them to demonstrate the procedures that they adopt in absence of modern tools for drawing various geometrical figures separately. I am very grateful to them as they easily agreed to demonstrate their understandings in different canvas for my research study. The video recordings of those demonstrations were carried out for further analysis. At the same moment, the observation process was conducted along with the collection of important field notes. I was amazed to see how different geometrical shapes can be construct easily with simple locally available materials. All those observation process

provided valuable insights on how traditional geometrical knowledge is practiced in drawing Paubha.

Field Notes

Field notes had been another vital tool for the collection of data in my research study. During the observation, I tried to conduct frequent short conversations with my research participants aiming to obtain additional helpful data for my study. The important ideas and points were noted down point wise for further analysis. The points were kept in order and short. I took field notes as record gathering vital information and events during my observation and interview. In that process, I tried my best to be more organized and accurate by documenting whatever I saw and heard exactly as they are. Field notes helped me regarding various activities performed by the research participants and their approaches while drawing paubha. The information about overall physical setting could be noted (Bogdan & Biklen, 1998). Further, the filed notes had also helped me to see whether I am being able to address my research questions in proper way or not.

Data Analysis and Interpretation

The information collected through various data collecting tools and techniques must be analyzed and interpreted wisely to make meaningful sense. It is really very difficult to draw the conclusion and relate the outcome with the research question and purpose. For this I transcribed the videos and audios that I have recorded during the interview. The data analysis process was then followed by systematic searching and arranging field notes that I have collected to amplify my understanding and to facilitate myself to present my findings in more effective ways (Bogdan &Biklen, 1992). I felt, this process demands the deep understanding of the researcher towards the data and competency to draw the meaning from them.

The data analysis and interpretation were carried out in systematic manner. Initially, the collected data was organized and followed by presenting the findings accordingly. For this, I transcribed the interviews that I conducted and noted down the important information in points. Then only the findings are interpreted with critical analysis regarding the related theories and experiences. I went through different literature, theories of the scholars and tried to put my insight on the basis of those theories and literatures. I performed data analysis and interpretation by considering these three parts as major steps (Creswell, 2012) of data analysis and interpretation in my research study with qualitative research design. While interpreting the data there is always some risk of misinterpretation of the collected data leading wrong conclusions (Krippendroff & Bock, 2008). Proper attention was given to retrospection of the data analysis process. For this I went through both the audio and video recordings of the observations and interviews with my research participants multiple times to make sure that I did not miss any vital information and event.

Quality Standards

Quality Standards are vital to ensure the Reliability and Validity of the research. According to Babbie (2004) 'reliability' is a matter of whether a particular technique, applied repeatedly to the same object, yields the same result each time and 'validity' refers to the extent to which an empirical measure adequately reflects the real meaning of the concept under consideration. Besides this my research aims to preserve the following quality standards:

Trustworthiness

Trustworthiness is an important quality standard that every researcher must think about. The major ways that the researchers had adopted while drawing the conclusion from the data must be taken under proper consideration to ensure that the

research study can be relied on (Graneheim & Ludman, 2003). I have always tried my best to maintained trustworthiness of my research through collection of data which I accomplished by going to real field, authenticity through appreciating social state, understandings the perspectives of participants. The research was conducted in a personal, social and natural setting.

I assured that the conducted research is a comprehensive approach using multiple theories, data and methods. To maintain credibility, I tried to ensure whether the findings were well presented as well as meaningful or not. By doing this, I could boost my confidence on my research findings. The research participants should be given equal chance to express their feelings, beliefs, opinions about the topic to ease the environment. Semi-structured questionnaire will be designed to ensure the dependability in the research.

Similarly, due care was given to the transferability in my research for which I will try to bring the findings of my research in practice for good. I tried to demonstrate how my research findings are equally applicable to other cultural groups on exploring mathematical practices in their day-to-day life.

Pedagogical Thoughtfulness

Pedagogical thoughtfulness is a quality of research writing that engages the reader (and also the writer) in thinking about educational issues, especially teaching and learning (Ellis & Bochner 2000; Howitt 2008). Through writing, readers should be made able to reflect on their own teaching. Through my research I tried to explore geometrical practices exercised during traditional Paubha drawing along with possible ways of its incorporation in mathematics teaching and learning approach. I believe the findings of my research poses high significance in classroom pedagogy and can

contribute well in successful mathematics learning (Manen, 2008). Besides this, being a researcher and a teacher, I will try to reflect on their own pedagogical practices.

Critical Reflexivity

According to Johnson (as cited in Afonso, 2007), ‘reflexivity involves self-awareness and critical self-reflection by the researcher on his or her potential biased and predispositions as these may affect the research process and conclusions. As a result, this criterion is powerful for envisioning the future and for empowering notion of educational process, not only to criticize, but also to act for the better future world. I found exploring hidden geometrical practices in newari traditional paubha drawing can be very promising in opening the doors for other different appealing behaviors of perceiving, framing and experiencing mathematical knowledge. I am extremely happy to share that my research raised a question on present pedagogical approaches by saying "The ways we teach in present mathematics class are really appropriate or should be modified?"

Praxis

To maintain this quality standard, I have tried to see the findings and information about the experiences of the research participants through various theoretical lenses. According to Taylor & Wallace (2007), praxis is concerned with the differences between natural constructs and those of human invention making the researchers take a critical approach to the phenomenon they are researching taking the power relationships in consideration. In other words, we can say that praxis also help me to understand and affect emotionally and intellectually within my pedagogical practices.

Ethical Considerations

To explore the geometrical practices in Newari Culture, I went through the prolonged engagement with my research participants about the topic. I focused to keep in mind that the nature of the research participants and the environment in which the research process is being carried out can change the outcome of the research. My research should be advantageous for the entire Newar community and it must be fruitful for the students and teachers from other cultural backgrounds (Punch, 2005). Hence, I emphasized on setting up a good relationship with my research participants and also a comfortable environment in which the research is going to carry out. For this, I informed my research participants about the purpose of my study and how they are important as research participants. A good rapport with them played vital role to assist a valuable information and data. It was the matter of concern to avoid unwanted information that may be presented during interviewing the research participants (Patton, 2002). At the same time, they were well informed well about their role in the research.

Furthermore, talking about the ethical considerations of the research, I have not done unavoidable force to the research participants in the aim of getting more information for my research. There was total freedom for them to get out from the research process whenever they desired. The process of the research would only be preceded after the permission of the research participants. Similarly, the confidentiality was promised which means information or data provided by them would be kept far from other people. Similarly, I was well aware that there must not be any type of physical and mental harm to the research participants during my research.

We can find researchers including information from others' research extensively. In other word, they try to present others work as their own work. With due care, without including any other researchers, I have tried to present my findings as it is; without any personal biasness. Another important ethical issue that I tried to maintain in my research is participants would not to be blamed for the providing fewer amount information while exploring ethno-geometry in traditional Newari art. I also ensured that the information provided is respected properly.

Chapter Summary

In this chapter, I have discussed about the major methods that guided me to conduct my research study in organized way. I tried to present an insight for the ways of choosing my research participants who have supported me by providing valuable data and information that can contribute in addressing my research questions. I tried to make sure that my research included all the demanding quality standards and the factors that can ensure the validity of the research method was taken in consideration. Analysis of the data was carried out to meet the requirement for the qualitative research since my research study has qualitative research design. Due care was paid on interpreting the data in wise way drawing the meaning crucial to uncover the cultural aspect of mathematics from the collected data. Furthermore, various ethical considerations that needed to be well cared about during my research study were well presented in this section.

CHAPTER IV

EMBEDDED GEOMETRICAL PRACTICES IN PAUBHA DRAWING

Chapter Overview

This chapter aimed to explore various geometrical practices that are embedded in traditional Paubha drawings. With substantial time spent with various proficient artists, I have come up with valuable insights which I discussed in this chapter thoroughly. In this chapter, I tried to present all those traditional mathematical approaches or methods embraced by the artists while drawing Paubha. For this I observed the traditional ways of drawing various geometrical figures by various artists and also talked about their techniques and methods to do so. Those artists have invested many decades drawing traditional Newari art. Hence, through this chapter I tried to address my first research question; 'How geometry is manifested in traditional newari art?'

What did I do to arrive to this chapter?

I tried to observe the drawings in the ways that I have never done before. As I have talked about the ethno-geometry in traditional Newari art before, it would be an important part to bring that knowledge in school classroom. On that notion I did very productive discussion with an expert of CDC. The main focus of the discussion was to have an idea about the space given by the curriculum to the cultural incorporation. I tried to analyze those traditional methods of drawing various geometrical figures and tried to compare them with what we have currently in teaching and learning mathematics as a classroom method. Besides this, I tried to talk with the two mathematics teachers about their perceptions on integrating culture in mathematics

classroom and introducing various cultural artifacts in mathematics classroom as teaching materials. Further, I discussed about the impact on the students by doing so.

I felt, the techniques used it the school classroom bear less meaning for the learners and so cultural incorporation can play significant role for successful learning of mathematics (Kline, 1990). I wanted to do that to address my second research question; 'How can we incorporate 'ethno-geometry' in the school curriculum?' Setting the bridge between the entho-geometry with lower secondary level mathematics teaching and learning approaches had been my prime concern.

As an art enthusiast, I usually get fascinated by all sort of drawings and so same things happened to the Paubha drawings as well. I saw plenty of entho-mathmatics embedded in Paubha. For instance, we can start with the frame or rectangular boundary made for drawing a Pabha within it. While preparing the rectangular boundary; in almost all drawings, we can see the basic concept of drawing a straight line and then a rectangle. I have tried to describe the systematic procedures in this chapter later on. Likewise, the painting consists of different other geometrical figures like triangles and circles. By studying about this I tried to present the cultural aspect of mathematics which is generally regarded as pure and neutral subject (Bishop, 1993; D'Ambrosio, 1990). Traditional Paubha drawings may be different according to the occasion in which they are made and the main purpose of drawing them. There are hundreds of varieties of figures which come under Paubha drawings. I have tried to address my both research questions and explore ethno-geometry in traditional paubha drawings by discussing about some of highly renowned Paubha paintings with higher mathematical potentials among all those figures.

Newari People

[Photograph of Newari People, 2018]. Retrieved from http://allnewsofnepal.blogspot.com/

Newars are the historical inhabitants of the Kathmandu Valley and some of its surrounding areas in Nepal. According to Nepal's census 2011, there are 1,321,933 Newars in the country. They are the nation's sixth-largest ethnic group, representing 5% of the population. Newars are known from their contributions to art, sculpture, architecture, culture, literature, music, industry, trade, agriculture and cuisine, and left their mark on the art of Central Asia. Similarly, 84.13% of Newars are Hindu and 15.31% are Buddhist, but most of the Newars practice both Hinduism and Buddhism. A Sanskrit inscription of Vasantadev in Tistung which is dated to be of 512 contains the phrase "greeting to the Nepals" indicating that the term "Nepal" was used to refer to both the country and the people. According to D.R. Regmi; a renowed historian, it came to be used for the inhabitants of the valley only in 17th century. So, Newar people have their own historical background. They are the creator of many cultural heritages, religious places, monuments etc. in Kathmandu Valley. The Lichhavis and

Mallas that arrived at different periods merged with the local indigenous Newar people adapting the culture, language and traditions of Newari people.

Newar people mostly follow Hinduism and Buddhism. However, nowadays, other religions like Christianity, Islam and other religion are also followed by the Newari people. Hindu and Buddhist Newar people have their own culture and tradition but we can find religious tolerance among Newar people following two different culture.

Newar are famous for their work in ancient art, architecture, sculpture, literature, music, trade and agriculture. The Newars are the creators of most examples of art and architecture in Nepal which specially flourish during more than 600 years long Lichhavi Dynasty. The temples and shrines in the Kathmandu valley which was built by the Newari artists have been highly recognized by the world. Seven UNESCO world Heritage sites of Kathmandu Valley show the aesthetic beauty and skills of Newari artists. Wood carvings, artistic work and portrait of god and goddesses in old residential houses, temples and rest houses are attraction for lots of tourists who come to visit Nepal. Among these arts and architecture, '*paubha'* is one of them.

What is "Paubha"?

The Newari people are the indigenous people of Kathmandu Valley. They have been noted for their astonishing works of spiritual art and architecture.

[Photograph of Paubha Display, 2018]. Retrieved from https://3.bp.blogspot.com/

Traditional Newari art is basically religious art. The traditional religious artwork of the Newari people is commonly known as '*Paubha*'. During an interview one of my research participants shared, "*The word Paubha came from a Sanskrit word Patra Bhatarak. It changes into Pati Bhalada in middle age. Later it became Paubha. Bhatarak generally means God. Patra means a plain surface with knowledge. Hence Paubha literally represents the knowledge related to the god. Likewise, Chaitya Bhatarak later changes into Chaityas"*. Newari paintings, called '*Paubha*' in Newari and '*Pata*' in Sanskrit, are usually rectangular in shape and are prepared from cotton woven specially to fit the dimensions require for each painting. Although it has been embraced by many people from different ethnic cultural background, traditionally paubha drawing is carried out by the Chitrakar family of the newar community. They

are called '*Poon Ta* ' in Newari language and as so in newari, making paubha drawings is called '*Poon Jya*'. *Paubha* usually portray figures of important divinities, *Mandalas* and monuments surrounded by various figures. These paintings are mostly created for religious purposes. Besides this, those paintings are used as aids to meditation as well.

The history of *Paubha* is immemorial. The oldest *Paubha* drawing in existence is the *Paubha* of *Amitabha Buddha*. It is preserved in Los Angeles County Museum and is believed to be from the 11th century. Some of the historical evidences suggest that the tradition of *'Paubha'* painting may go beyond 7th century. One of my research participant shared, " *If we talk on the basis of record we have, to know about typical newari paubha drawing, we need to get back to Malla Period although it is much older. The painting dated around 13th century are spectacular but to reach in that height it has been changing many centuries. According to the various other sources, on 4th century a Chinese scholar Phai Yan said that the people of this region did not enjoy having foreigners on their land. But the people at that time with wooden ornaments on their ears seemed to be quite good artists. Almost all the houses have different pictures painted on their wall. It means the trend of painting is much older than we think. Other evidences of the wall painting that we used to do can be seen on Bhaktapur Durbar Square Museum*." From the earlier seventh century, visitors have noted the skill of Newar artists and craftsmen who left their influence on the art of Tibet and China. Newars introduced the lost-wax technique into Bhutan and they were commissioned to paint murals on the walls of monasteries there. Further, these traditional artworks travelled through China resulting the evolution of Tibetan Thangkas. During the interview, I encountered the fact that there is common misconception of taking Paubha drawing as Thangkas. According to my research

participant who has been respected for his work and contribution in traditional newari Paubha drawings, "*The main difference between Newari Paubha and Thanka drawing can be studied specially on two bases; the religious source and the technique of drawings.*" It is very hard for an ordinary art enthusiast to distinguish regarding those aspects.

The *Paubhas* consists of surprising level of symmetry and geometry. By incorporating the knowledge embedded in traditional Paubha drawings we can motivate students to see mathematics not only as the pure subject to learn but also its link with our day-to-day activities. Mathematics used to be considered as global knowledge and was thought as an irrelevant to human culture. Hence, learners were prepared to compete in global world. After the recognition of cultural mathematics, effective discussion has held to include cultural mathematics in mathematics pedagogical system. Such mathematics which incorporates the cultural nature of mathematics was termed as "ethnomathematics". Brazilian mathematician UbiratanD'Ambrosio **(**1985**)** has defined ethnomathematics as intersections of culture, historical traditions, sociocultural roots, and mathematics. It helps in minimizing colonizing and hegemonic dominance of western mathematics over local mathematics.

Besides this, in present context, paubha drawings escaped from the traditional and cultural point of view and have been commercialized as well. There are high demands of these drawings in national and international level. It has contributed a lot in uncovering Newari art in international level.

The composition of a *Paubha* that depicts a Mandala is inescapably dictated by the geometry pattern.

[Photograph of Tihar Mandala, 2018]. Retrived from https://thegettingthere.com/2012/11/15/kathmandu-hot-lemons-and-space-invaders/tihar-mandala/

All these things suggest that the creation of a *Paubha* drawing demands tons of knowledge about the Buddhism, Hinduism, Spirituality and Meditation. At the same time what we cannot ignore the fact that the artist must contain wide knowledge about Geometry or varieties of Geometrical figures while drawing a Paubha. There are many possibilities to make the mathematics (geometry) learning more convenient and efficient if those geometrical ideas and knowledge are well explored. Various traditional methods of drawing such geometrical figures can be presented in classroom as an ethno-modeling (Rosa & Orey, 2010). This can create an opportunity for the learners to get out of their classroom and monotonous teaching and learning approaches. I believe it can make both the learners and the teachers not to focus on

the product of learning mathematics but also to see mathematics in various cultural practices. The various methods of drawing different geometrical figures can be brought in classroom as a cultural incorporation for the students' better learning (Rosa & Orey, 2013, as cited in Gay, 2000, p. 29). Similarly, it can contribute significantly in the preservation of traditional *Paubha* drawings as it is now being regarded as an endangered artwork. I believe empowerment of the cultures; falling under minorities can be ensured with the adaptation of the ethnomathematics in teaching and learning mathematics approaches.

Materials used in drawing Paubha

Traditionally, Paubha paintings are drawn in specially woven cloth. The piece of cloth was believed to be woven by the pure virgin. Paubha paintings are drawn by the artists with calm heart and brain. The colors used in drawing Paubha are considered as pure and sacred. They are made from grinding different mineral stones, flowers and leaves. For example, limestone is used to make white color and in some cases, soil is also used. Those colors are mixed or prepared in various small clay pots. They are called 'Milacha'. The colors are mixed in fix proportion to get desire color. The technique can be further studied and introduced in mathematics classroom to explain the concept of ration and proportion. Hence, basically, locally available materials prepared with local knowledge are used while drawing Paubha. Since, drawing Paubha is a part of culture and regarded as a holy task to perform, the artist wait for a special day and a special

time to start his work.There is even trend of facing particular drawing; facing east while drawing Paubha. The artists and other local people believe that performing these activities while drawing Paubha awakens the knowledge and intelligence of the artists.

One of the major components of Paubha drawing is that they use of many types of '*Kwanna*'s by an artist. Some of the special Paubhas are even painted with gold and silver mixed with various colors. Besides this, some other materials used while drawing Paubha are *Bataan*, for drawing perpendicular and parallel lines. A simple wooden shaft is used to draw straight lines. A rope or tread along with charcoal, flour and oil. In present days we can see many artists using modern water colors, poster color and acrylic for drawing Paubha. Paubhas drawn by using these types of modern colors are basically commercial.

Bataan

Bataan is a traditional tool specially used for drawing perpendicular lines. It is often used by carpenters because of its multiple uses. Initially it was made by the wood but nowadays it can make by the steel as well. The tool might be new for the students although it has been in practice for thousands of years in drawing various traditional drawings. According to one of my research participants, it is generally made up of pieces of wood while we can also see as a metal in some cases. Wood is locally available material which is quite convenient to find. In other word, if

we are to prepare this tool to bring it in the mathematics classroom, it can be prepared with ease by the students investing minimum amount of time.

Bringing this in mathematics classroom can lead to culturally responsive teaching since "using the cultural characteristics, experiences, and perspectives of ethnically diverse students as conduits for teaching them more effectively" (Gay, 2002, p.106). Therefore, students would be fonder to use it as a manipulative for better learning. Pant (2015) wrote, "Today, many of us argue that geometry is one of the most "useful portions" of school mathematics, and it is believed that it can be easily discussed in the classroom with the help of manipulatives" (p.53). This tool is used as the modern day set-squares to draw perpendicular lines and is equally useful in drawing parallel lines as well.

Besides this, the students can be instructed to develop such geometrical instruments by their own which will further boost their mathematics learning. Owing to the research conducted by Rai (2016), another important advantage of demonstrating Bataan in mathematics classroom is that by taking this as a reference, the students can be further explained about the proper use of modern day mathematical instruments like set squares. What I believe through this, students can be provided necessary opportunities to construct knowledge rather than perceiving mathematical knowledge as granted by the Europeans. These tools can help the learners to know about the ancient techniques of developing and manipulating various locally available materials into the mathematics learning tools. Besides this, it can assist the learners to critically analyze the historical knowledge and construct the new knowledge accordingly.

Mandala

Paubha represents all sorts of traditional drawings used in Newari culture. Those all drawings are considered highly sacred and are made in special occasions for certain special purpose. In that sense we can say that the drawings posses deep meaning; from simply lifestyles and culture to the resemblance of entire events of some important incident in holy books and legends. Being a paubha artist demands years of study and dedication. A Mandala can be taken as one of the good examples. It is not just a mere drawing.

Mandala has been an important part of the paubha drawings. According to Milan Shakya, Central Department of Culture, Tribhuvan University, Kirtipur (Basic Concept of Mandala, 2000), Mandala means circle and is derived from the Sanskrit.

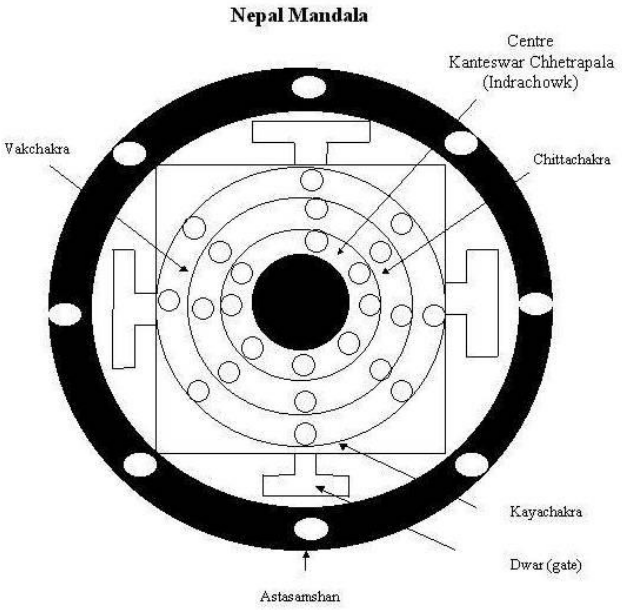
[Photograph of Newari Mandala, 2018]. Retrieved from https://johnorser.files.wordpress.com/2014/04/paubina-2013-npl-u1.jpg

The meaning of mandala is almost same in all beliefs but the types and colors used in different mandalas may resemble various meanings.

As shown in an example of a mandala shown in figure, a mandala comprises of various geometrical shapes; mainly circles, rectangles, squares and triangles. Basically, we can see the use of squares, triangles and circles while drawing mandala. Hence, it can be said that "there is no sense in regarding mathematics learning as abstract and culture free" (Bishop, Hart, Lerman, and Nunes, 1993, p.1). All mandalas

have a center called *Bindu*, which is a point. With this, we can introduce various geometrical shapes to the students. It may seem complex for the students but with appropriate use of various colors mandalas can be really eye catching. At the same time, they can construct their understanding through proper observations of such cultural artifacts (Rosa & Orey, 2008).

We can present a great example of concepts of concentric circles, squares and triangles using mandalas in our pedagogical approaches. One of the major advantages of doing this is students get an opportunity of get out of their classroom and learns geometrical shapes in artistic way. They can be made familiar with the fact that those geometrical shapes are not just bounded in their books and the concepts about those shapes and figures can be constructed remaining beyond formal academic settings (Bandeira & Lucena, 2004). I am really glad that our ancestors have been using them to create a real masterpiece which is of deep meaning and knowledge at the same time. For those who are staying aside while learning geometry, this can be an effective way to drag them in to the imagination and beauty of mathematics in different way (Orey, 2000). This way of addressing cultural diversity in the classroom by bringing possible linkage between their cultural practices and mathematics can be one of the efficient



[Photograph of Nepal Mandal, 2018]. Retrieved from http://www.aioiyama.net/lrc/papers/cbhnm-ppr-4.htm

ways in teaching and learning mathematics (Francois, 2010). I believe that it can further assist in successful geometry learning.

To sum up, as shown in the fig(ii), with the help of mandala we can show the inter connection between various geometrical figures. For instance, we can see a circle within a square, if carefully observed the mid points of each side of the square will be touched by only four points on the circumference of the circle. Similarly, the four vertices of the square will be the four points on the circumference of the outer circle. These understanding can be developed by letting the students discuss in groups and they can even be instructed to come up with their own new creation using their acquired knowledge. In other words, an environment for social interaction can be created among the students for acquiring the mathematical knowledge taking equal consideration of their prior knowledge.

Bhaitika Mandala

Bhaitika is a special event celebrated by all Hindus in the auspicious occasion of the Tihar festival each year. It has been one of the major occasions for the Newari people from very long period of time. This is the moment in which brothers and sisters try to show their love and care towards each other in the best way they could.

If we talk about the traditional ways of celebrating bhaitika, newari people have their own typical way of celebrating it. The setting for the bhaitika seems very appealing and also needs a good preparation. The major component of this event is drawing Bhaitika Mandala. The

number of mandalas may differ according to the number of brothers involved in bhaitika but the lower and upper madala always represent their major god or deities. Generally, the shape of the mandala is circular in shape but may vary slightly even among the Newari people.

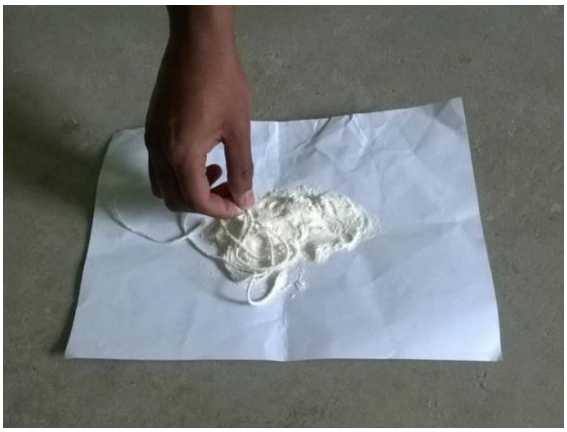
As we can see in the picture, the mandala is made in circular shape by using oil, flour and various other grains. From the perspective of the mathematics, the mandala depicts the concept of the concentric circles. It can be used to show how many circles can be drawn taking the same point as a center. Along with the students, it gives equal opportunity for the teacher to acquire some idea about mathematics in Newari culture and motivate him to use such knowledge from other culture respectfully (Zeichner, 1996). There is very low possibility that the students mathematics classroom of Nepal are not familiar with the Bhaitika Mandala. It can be an artistic way for the explanation of the concentric circle which I think would be fun to do. In this way, presenting the Bhaitika Mandala in teaching geometry can contribute significantly in solving the problem that may arise while explaining about the concentric circles. "When practical or culturally-based problems are examined in a proper social context, the practical mathematics of social groups is not trivial because they reflect themes that are profoundly linked to the daily lives of student" (Rosa & Orey, 2006, p.34).

Traditional Methods of Drawing: Geometrical Figures

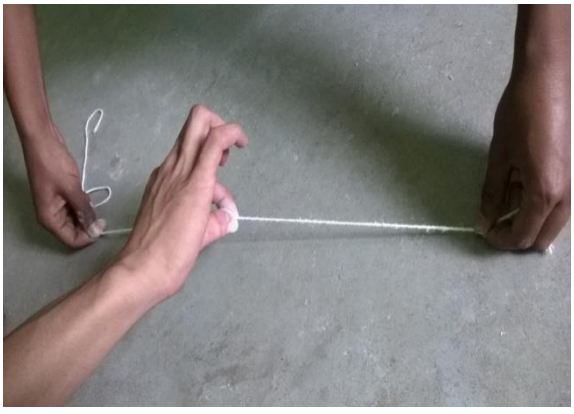
A Straight line

Since every Paubha drawings are drawn within a rectangular or square boundary, drawing a straight line can be considered as the starting step of the drawings. An expert can directly draw a straight line manually with an ease using is

experience but if the drawing is large and is to be made on certain plain on the ground or on the wall; they too need to adopt a special method to draw a straight line.



To draw a straight line, the basic material used is a long rope and some flour or charcoal. According to my research participant, *"The rope is used to draw a straight base line. It is not possible to draw a straight line using pencil and the rope only. Thus the rope is put in the color and the sketch will be drawn by hitting the rope and having the print on the paper. The same robe will be used to draw a square/rectangular figure as well. The idea of diagonal concept will be used. The idea of midpoint (diagonals bisect each other) also drawn with the help of the same rope".* Taking about the major steps in drawing a straight line, at first the desired length of the rope is taken, and then the rope is colored with the charcoal or flour. The rope can be simply made wet with water or oil as well. The only purpose of this is to have a perfect marking on the surface.



After this, it is placed on the surface where the line will be made. The rope is fixed at two ends while it is slightly pulled upward at the middle to tap on the surface. The tapping of the rope on the surface leaves the mark of a straight line on the surface. The method seems quite simple and different from the way we draw a straight line in our todays' mathematics classroom.

What we do generally to construct a straight line is simply drawing a line with the help of a scale and a pencil within the exercise book most of the time. This method is generally used in making mandalas on the ground on special occasions like Tihar. Besides this, we can also see some artists using wooden shaft to draw a straight line. To find the mid-point of the line, the rope is simply folded half and is measured from any end of the line to mark the mid-point of the line.

This is method of making a straight line is quite convincing; we can draw a straight line of the desired length without using a scale or any other geometrical tool. Besides this, it suggests that ethno-mathematical approaches can contribute significantly in facilitating the classroom's various pedagogical practices (Borba, 1993). As we can see that the materials used are quite common and are more convenient to use. These classroom materials and the methods can be further included to enhance mathematical curriculum and achieve its goal without difficulty. I hope this will assist a lot in developing the confidence of the students and they will feel no difficulties in drawing a straight line in any size they desire.

Circle

To acquire necessary important data for my research study, I spent many hours discussing about the Paubha drawing with my research participants. I had to visit their home and in some cases spent an entire day hoping to uncover geometrical knowledge in Paubha drawings. After spending some remarkable time discussing about the Paubha with various professional in Paubha drawings, it was found that circle is the fundamental element of the drawing. It is widely used in most of the drawings as a basis of other geometrical figure like

squares, rectangles and triangles. Newari artist have developed their own way to draw these figures (Bassanezi, 2002) just like other cultural groups to meet their requirements. For drawing a circle in traditional way, at first a point is marked at the desired position. The point is called Bindu which later will become the center of the circle. A thread is taken and is tied with a pencil carefully. A desired length for making a circle is taken. With this, the concept of the radius can be introduced to the students. Then, by fixing an end at the Bindu (center), with that length as a radius, a circle is drawn by revolving the pencil around the Bindu.

On the contrary, what we have in our conventional mathematics classroom is the use of mathematical instrument; Geometrical Compass. Students are trained to draw the circle using a geometrical compass within their exercise book most of the time. The circle is drawn by fixing one tip of the compass on the desired point and revolving the other part with a pencil attached to it around the fixed point.

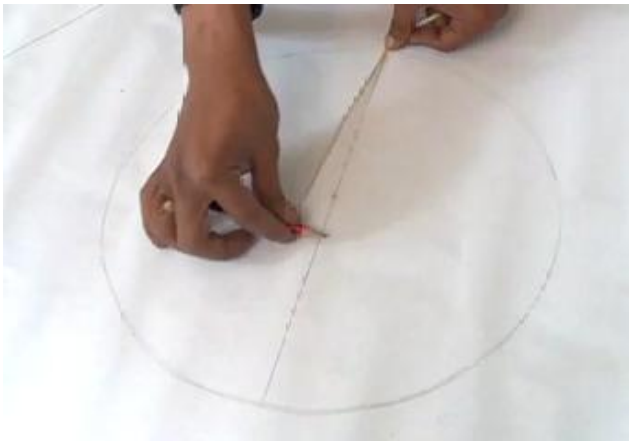
The method used by the paubha artist seems to be very simple and fascinating for the students. But while drawing the circle, there are still chances of committing some mistakes and may be difficult to draw precisely. It depends upon the posture of hand and positioning the pencil tied with the thread. Generally, the thread is tied at the lowest part possible. It assists in minimizing the possible errors or mistakes that may be done while drawing the circle. While drawing the circle, due care must be paid on moving the pencil uniformly without disturbing the hand position.

In this way, we can easily demonstrated that how a circle of any size can be drawn without using modern day mathematical (geometrical) instruments. It can be really interesting for the students to learn. One of the mathematics teacher as my research participant said, "*The reason for not enjoying learning mathematics depends upon the teacher. It depends upon how they teach in the class. To be a good*

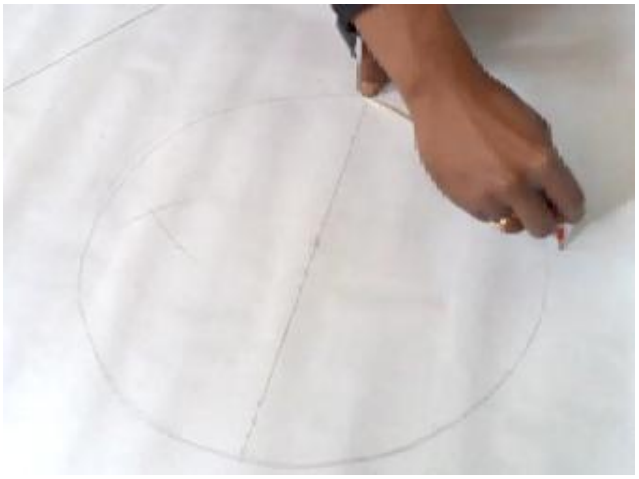
mathematics teacher, I am always working on how I can make my teaching more fun and fruitful." This traditional way of making a circle may not be known to the students but is of great value. That's why there is need of incorporation of such cultural approaches in school curriculum. Ethno-mathematics can bring students cultural backgrounds in front of the entire classroom in more effective way (Rosa, 2010). This cultural approaches introduced to the students is comparatively dissimilar from the classroom approaches and so can construct knowledge in different way which they are more likely to remember for the longer time.

Drawing a Square

A square is an additional important geometrical figure extensively used in the traditional Paubha drawings. The uses of squares are highly noticeable especially in various mandalas.



As per local knowledge square are mostly drawn with the help of the circle. At first a circle is drawn with the same method that has been discussed previously. It is followed by drawing a diameter, considering on which side the vertices of the square are needed. With the help of the thread tied with the pencil, a length slightly longer than the half of the diameter is taken.



Then the intersecting arcs are drawn on the opposite sides of the diameter from both ends of the diameter. The process is carried

on carefully to find the accurate intersecting arcs.

A straight line passing through the intersection point of two arcs on the opposite sides of the diameter is drawn which will meet on the circumference of the circle on both sides. It leads to the finding of two points on the circumference of the circle providing two more required vertices for the square that we were drawing. The four points act as the vertices of the square. The points are then joined with the help of the wooden shaft or any other straight too to complete the drawing of the square.

As a mathematics learner and a teacher the way I used to construct a square was:

1. Drawing a straight line with desired length.
2. Constructing a right angle on both ends of the line.
3. Measuring the length of the line drawn previously with a mathematical compass to cut an arc on the both perpendicular lines.
4. The intersecting point of the arc and the perpendicular line on both ends of the line would give two remaining vertices of the square

The construction of square is carried out according to the cultural approach. Such methods brought from the traditional Paubha drawing are more likely to accelerate the mathematical learning. Ethno-mathematics in classroom pedagogy by linking cultural aspect of mathematics with curriculum can help out in acquiring mathematical knowledge as ethno-knowledge by the students (Borba, 1993).

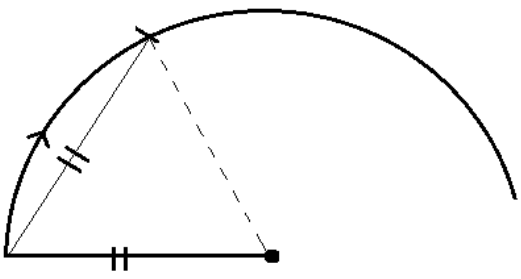
According to Rosa and Orey (2006), it is more likely to empower the students belonging to minority groups in noticeable extent by making mathematics learning more inclusive (KU, 2008). At the same time, it makes the educators think about the possibilities of proper incorporation of ethno knowledge from other cultural groups in the mathematics classroom.

The method for drawing square was quite different and fascinating at the same time. It was different from the way I used to teach construction of square as a mathematics teacher. I believe that it can convey the message to the students that they are free to come up with their own unique ideas to construct various geometrical figures. Through this practice they can self-reflect their status in learning mathematics and can also develop the confidence in the same process. Likewise, I think they can develop the feeling of being independent in learning mathematical ideas which is another important objective of education.

Drawing an Equilateral Triangle

While discussing about the method of drawing an equilateral triangle, I felt the process is quite interesting. It is drawing an equilateral triangle with the help of semi-circle. The process starts with drawing a line of the length with the length of a side of an equilateral triangle. Further, the process is carried out with the same materials that have been discussed earlier.

After drawing the line, a semi-circle is drawn taking the radius equal to that line. An arc is cut with the same length. That gives us the third vertex for the equilateral triangle. The two ends of the line are



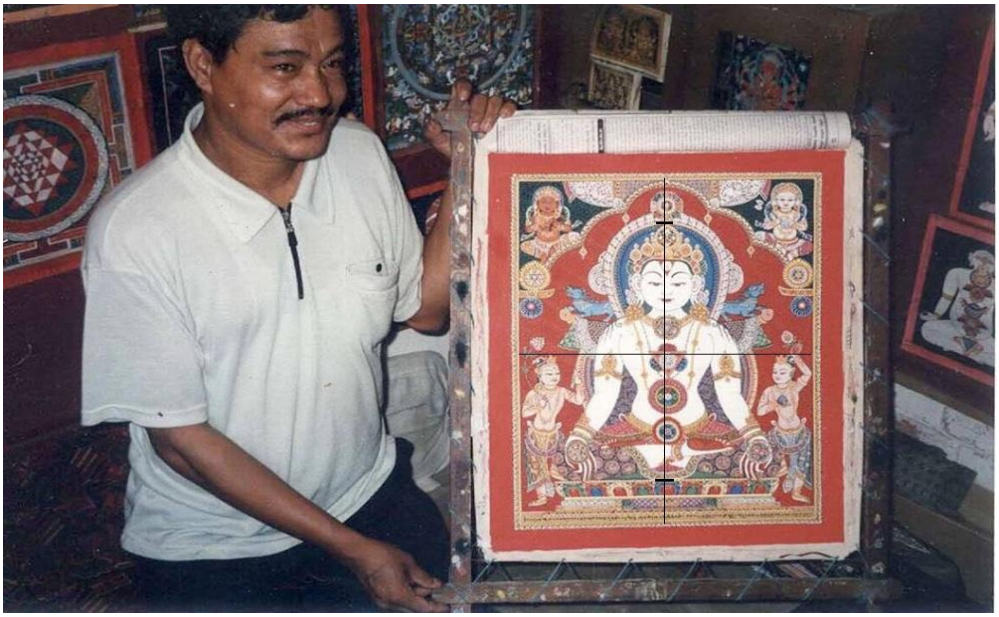
taken as the remaining two vertices of the triangle. While teaching construction of an equilateral triangle, what I felt is that students often fail to draw the sense that the third vertex of an equilateral triangle is actually an intersection point of two circles drawn with the same radius from the opposite ends of the line we drew at first.

The method that we generally have in our present days' mathematics classroom is;

1. Construct a straight line with desired length; length of a side of the triangle.
2. Measure the length of the line with the help of mathematical compass to cut two intersecting arcs on either side of the line.
3. The intersecting point of the two arcs would give the third vertex of the equilateral triangle.

Above mentioned approach of constructing the equilateral triangle by the Paubha artists may seem similar to the methods taught in mathematics classroom currently in some ways but the additional properties of an equilateral triangle and circle can be observed. According to Borba, (1993), Ethno-mathematics can enable students to see the status of school pedagogies that we have currently in mathematics classroom. They can compare classroom pedagogies with cultural approaches. Rosa and Orey (2003) stated that the students get motivated to search the relevancy of other cultural practices with the school curriculum if they found the linking of cultural approaches more fruitful and fun. In another word, it seems that incorporation of ethno-mathematics in classroom pedagogies has many benefits.

Symmetry in Paubha



[Photograph of Late Gyankar Bajracharya with his Paubha drawing, 2018]. Retrieved from https://www.facebook.com/BodhisattvaGallery/photos/

Another central specialty of the traditional Newari painting is its symmetry. Symmetry is crucial for making the painting more eye-catching and uniformlypainted. As shown in the picture; a Paubha drawing by one of the prominent Paubha artists late Gyankar Bajracharya, we can see the symmetrical aspects of Paubha drawing.

We can see that the picture of the most important deity is drawn at the middle of the canvas accompanied by various others on the corners. The gap between the deity and the border line on both upper and lower part is almost same. Though hardly visible, to align the body of the deities in the middle, the ample range of geometrical knowledge and skills need to be brought under practice. One of my research participants shared, *"Maintaining symmetry has been one of the major quality of the traditional paubha drawings one cannot ignore"*. In another word, to master such skill, we cannot deny the fact that one must acquire certain level of geometrical concepts; concepts about the mid-point, about bisecting sides of the figures like

rectangle and squares and so on. Besides this, the use of the concepts of ratios is of great importance for the same task.

The idea of aligning the figure of body structure in paubha at the centre of the canvas is very interesting. According to Mr. Sundar Shrestha; a professional paubha artist, the steps of aligning the figure at the centre of canvas is described below.

1. At first, the width of the canvas is measured by using a thread. Proper attention is paid for making the thread straight enough to avoid possible errors. Same process is carried out on the bottom part of the canvas to make sure that the measurement is precisely done.

2. Then, the thread of length equal to width of a canvas is folded into half. One end of the half folded thread is placed to one of the end of canvas and other end of thread to the middle part of the canvas. The end of the tread at the middle of canvas is marked by using pencil. The mark of pencil in canvas aligns itself in the middle of width of canvas. The process is repeated for the several times in the lower part of length of canvas and the middle section of the canvas is determined.

3. Through the process mentioned in step 2, we get many points align themselves at the middle of the canvas.

Those marks of pencil are joined with the help of a wooden shaft or any other tool to obtain a complete straight line.

4. Before drawing the picture of any deity in the canvas, an estimation of the length of figure on the canvas is done. A little space is left at the top of canvas by aligning the tread on the line which is drawn previously at the middle of the canvas by a pencil. Upper end of the thread where a little spaced is left at the top is then marked with a pencil.

5. Without disturbing the length of the thread used, same process is carried out to leave the same amount of gap at the bottom of the canvas. It means, the length of canvas from the upper end of canvas is measured and the lower end of the thread is marked.

6. By doing this, we will obtain two marks on the line drawn at the centre of the canvas. The space between those two marks is used to draw the picture of the deity then after.

7. Further, the space obtained is divided into 7.5 parts.

Golden Ratio and its Connection with Paubha

During the interview and discussion with Mr. Sundar Shrestha about the alignment of the body of a deity at the middle of the canvas, I found an interesting link of drawing body structure of deities with the golden ratio. After his explanation about the estimation of the space for drawing the body of the deity, I was told that the space determined is divided into 7.5 parts. The further discussion on 'Why it is divided into 7.5 parts?' the embedded concept of the golden ratio in Paubha drawing comes onto surface.

Golden Ratio

The golden ratio is the number $\Phi = \frac{1+\sqrt{5}}{2}$ which is equivalent to 1.618033989. It is also called golden mean, golden proportion, golden number, *seetiodivina*, magic ratio, and the Fibonacci series.

The golden proportion was first described by an Italian Mathematician named Leonardo Da Pisa (also known as Fibonacci – son of Bonacci). He describes an interesting pattern of numbers which is 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, … In this sequence, the first two numbers are 1, 1 and then the remaining sequence is sum of the two previous elements. This pattern is named as Fibonacci sequence in which as the sequence progresses, the ratio of one number to its proceeding number is about 1.6. Further, the ratio approaches 1.6180339887459895 and more.

Fett (2006, as cited in Wasler, 2001) defines golden ratio as a line segment that is divided into the ratio of the larger segment being related to the smaller segment exactly as the whole segment is related to the larger segment.

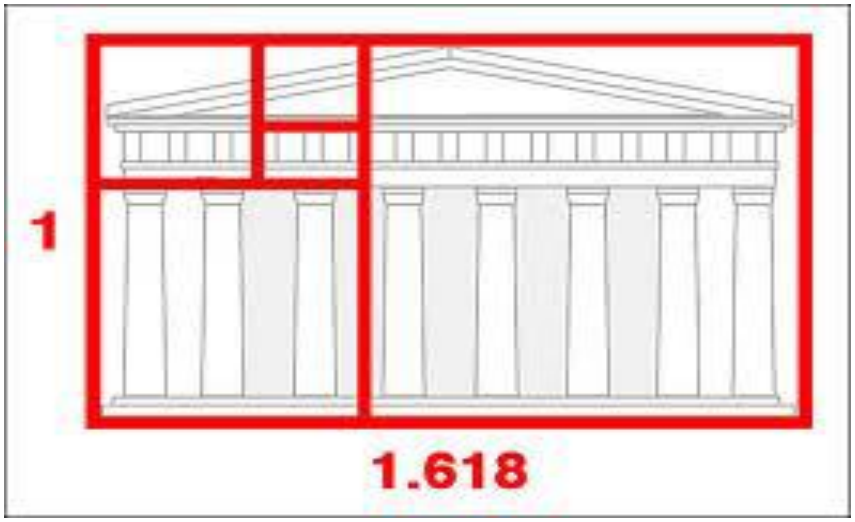
Suppose a line is of length ‘l’ is taken and it is broken into two pieces of length ‘*a*’ and ‘*b*’ such that a + b = l and ‘*a*’ is a longer length. Now, the ratio with the

property $\frac{a+b}{a} = \frac{a}{b}$ is called the golden ratio. It is called the *golden* ratio because among the ancient Greeks it was thought that this ratio is the most pleasing to the eye.

A rectangle is called a golden rectangle if the ratio two adjacent sides of the rectangle is equal to Φ. Let the length of sides of a rectangle be Φ and 1 unit then $\frac{1}{\Phi} = \frac{-1+\sqrt{5}}{2}$. The rectangle is then considered as golden rectangle. It is possible to split a golden rectangle into smaller golden rectangle and again further to smaller golden rectangle.

The golden ratio and golden rectangle are widely present in ancient art and architecture. Some famous example of a golden rectangle in architecture is the Parthenon of Ancient Greece. Some of the great artists such as Michelangelo, Raphael, and Leonardo da Vinci used the divine proportion in their paintings and sculptures. Leonardo Da Vinci presented the idea of golden ratio in most well-known paintings – *Mona Lisa, The Last Supper,* and *The Vitruvian Man.*

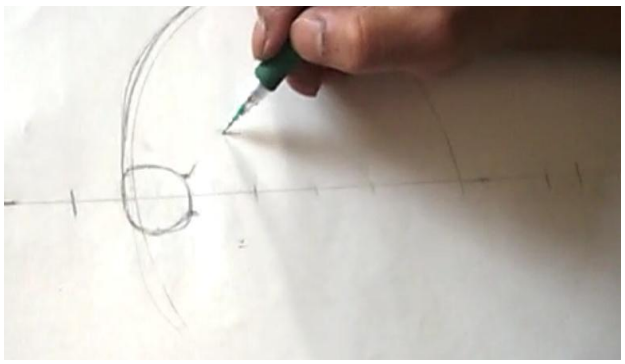
It is found that some of the great artists used the idea of golden ratio in arts and architecture while many artists have unconsciously employed golden proportions in their art. According to Ackermann, (1895), the irregular inequality in art is not as beautiful as the use of golden proportion. Golden proportions are pleasing to both hand and eye.



[Photograph of illustration of The Golden Ratio, 2018]. Retrieved from http://www2.rgu.ac.uk/subj/ats/TeachingWeb/teaching/t22/Wk6-Composition/Composition01.htm

The Golden Ratio Embedded in Paubha

The sketching of the deities in Paubha is carried out with the concept of proportion of the total body size with the size of the head. Basically, it is considered that the entire size of the body is approximately about 7.5 times of the size of the head. After determining the size of the body and aligning it at the centre of the canvas, the desired size is divided into 7.5 sections with the help of the rope or the brush.



The artist starts sketching the figure afterwards. The figure comprises of various other anatomical concepts. It is believed that the body of the deity is graceful and meets perfection if the *Navel* of the body lies at the end of the third partition of the figure. This leaves the bottom part of the body with 4.5 parts of the total 7.5 parts.

Relating it with the Concept of Golden Ratio

As it is clearly noticed that the figure with 7.5 partitions is divided into two parts; one with 3 partitions (Upper) and another with 4.5 partitions (Lower), the relation between those parts can lead to the concept of the golden ratio.

Mathematical Testing. For *a* and *b* as the partitions of any structure or a body with *a* as larger partition, the ratio $\frac{a+b}{a}$ is if equal to the ratio $\frac{a}{b}$, then the ratio is called Golden Ratio.

To check if the idea of body proportions in *Paubha* satisfies the concept of the golden ratio, following mathematical calculations are performed:

a. Taking the ratio of the total partitions in the entire figure with the partition with more partitions (Lower)

   i.e. $\frac{Total\ \ Partitions}{Partitions\ \ in\ larger\ \ part}$

   $= \frac{7.5}{4.5}$

   = 1.66 = R1 (let)

b. Taking the ratio of the Lower part and the Upper part

   i.e. $\frac{Lower\ \ partitions}{Upper\ \ partitions}$

$= \frac{4.5}{3}$

= 1.5 = R2 (let)

Findings

With the above mathematical calculations regarding the ratios of partitions used while drawing the figure of the deity, it can be noticed that R1~R2. This leads to the conclusion that the artists have been using mathematical idea of the golden ratio even though they are unaware of the concept of golden ratio. During the interview it was found that the artist is not even familiar with *The Golden Ratio* but still, the idea being used in drawing *Paubha* art was closely related to the golden ratio.

Paubha Art as a Tool/Process for Culturally Relevant Pedagogy (CRP)

It is very challenging for any teacher to teach efficiently in any classroom. One of the core reasons for this can be the classroom structure. The classroom structure may consist of the students from diverse cultural groups. It means the teachers are highly likely to face students whose culture, ethnicity, language, race and social backgrounds differ from one another (Howard, 2003). I believe it is the duty of every teacher to be able to address all those multiple culture in the classroom during teaching and learning process. The learners may feel difficulties in learning since their culture differ from one another and the teaching pedagogy in the classroom may favor any one dominant culture. It can create hindrances in learning process. Hence, there is the need of reform in classroom pedagogy. An introduction of traditional Paubha drawing in teaching and learning geometry can empower the students from Newari culture who are regarded as the minority group in Nepal. An idea of culturally relevant pedagogy (CRP) assists teachers to set up sound environment in which the home culture of students and the school culture work together for the better learning of the students. CRP pays more attention in respecting diverse culture of the students

in the classroom and tries to enhance the students' achievement (Ladson-Billings, 1995). While talking with an expert in curriculum design for my research study, he shared," *It will be great incorporating culture in the mathematics classroom. There are more possibilities of using various Newari art and artifacts in mathematics classroom. It is beneficial for both teachers and students; it will be easier for the students to develop understanding using such materials whereas teachers will get chance to learn themselves about the culture and can even conduct further research and study on it. That is why our curriculum has granted this provision even in written form.*"

In present mathematics classrooms we can hardly find the place for students' cultural backgrounds which can lead to unsuccessful learning. For the cultural integrity of the students and to achieve significantly in academics, CRP can contribute a lot (Ladson-Billing, 1995). According to Hackett, teachers need to develop a "strong cultural identity responsible for teaching the whole child by teaching values, skills, knowledge for school success and participation in society, linking classroom teaching to out-of-school personal experiences and community situations" (Hackett, 2003, p. 329). CRP ensures the ability of the teacher to teach in cross-cultural or multi-cultural classroom setting. Besides this, CRP can create ideal environment with sound relationship between teacher and students. Similarly, with cultural equity in the classroom, it can empower the students enhancing their academic competence, personal confidence, courage, and the will to act.

Hence, the introduction of a traditional paubha art; introducing various cultural knowledge and procedures for practicing geometrical knowledge can relate local knowledge with the mainstream academic teaching approaches.

Cultural Project-Based Learning (CPBL)

Project-Based Learning (PBL) is a systematic teaching approach that engages students in learning knowledge and skills and that shifts away from the classroom practices of short, isolated, teacher-centered lessons and instead emphasizes learning activities that are long-term, interdisciplinary, and student-centered. PBL establishes connection to life outside the classroom, addressing real-world concerns, and developing real-world skills.

The idea of Project Based Learning helps learners to engage in meaning making process. But to give an identity to the cultures that people have been practicing around the world through the project based learning is the need of today's world. It is necessary to expand limitations of the project-based learning as a tool to empower learners to understand the meaning of what they are learning in mathematics as well as to explore socio-cultural identities.

CPBL has been taken as an alternative way to empower learners by engaging them in socially and culturally authentic problems and projects in order to understand the mathematics that used to be taught in isolation. If we see the classroom culture that we are engaged, majority teachers are still teaching skills and drills in such ways that serve only a select set of students. These teachers need to learn how to address students' voice. An expert in curriculum development said, " *In the context of government schools, the teachers are more trained and qualified but the problem is some of them are not using the knowledge they acquired in the training properly. Hence, majority of the low achievers in mathematics are from the government schools regardless of the well trained teachers and a good curriculum.*" A series of workshops for teachers have been practiced in the context of Nepal. The discussion in the workshops were about ethno-projects and helped teachers to think out of the

regular routine of chalk and talk and expand their horizon to the level where they themselves create the draft of ideas that could potentially become engaged in projects with their students (Neupane & Sharma, 2016).

It is necessary to take an account of the development of the mathematical development, which needs to be critical in relations to its purpose of creativity and innovative shift towards a more inclusive teaching and learning framework described as an ethnoshift. Ethno shifts are paradigm processes and where the socio-cultural experiences of the learners are respectfully brought into the classroom discussion (Rosa, 2010).

Gardner (1993) has discussed about the various intelligence of learners. Everyone is culturally intelligent, and like any intelligence can be improved. We learn better if learning is connected with our own experience and cultural context. Learning becomes more meaningful to the individual and offers a sense of identity (Neupane, 2016).

Integrating CPBL with Paubha Art

There is no doubt that projects have a component of integrating authentic context and real world problems, but it often miss the socio-cultural notion of teaching and learning as well as they may not always be culturally relevant. Mathematics teaching and learning must ensure that there are enough culturally relevant projects provided to the students. An introduction to the Paubha art in mathematics classroom through projects can be really productive. An expert in ma thematic curriculum design said, "*Project works in mathematics are to be designed in such a way that the students will search local knowledge. The mathematics book designed by the Curriculum Development Committee (CDC) and which are used as the mathematics course book in all government schools has included such problems*

or works in almost all the topics in the mathematics book." It can present students with an opportunity to get familiar with the cultural practices besides their own and the ways of drawing various geometrical shapes by Newar community remaining outside the mainstream education approaches while respecting it at the same time. He further added, "*Students in any classroom have grown up under different cultures and practices. One of the major reasons for the low performance of those students in mathematics is that the way we teach in classroom may act as imposing mathematics on them. Cultural incorporation can relieve the students from those feelings in many ways*". Ethno-projects help to increase demonstrations of ethnic identity of the members of different cultural groups (Naveira, 2005). Cultural scaffolding can be applied to facilitate teaching and learning processes when students are introduced to new contents. Cultural scaffolding means that teachers must use the local culture and their own rich community contexts and experiences to facilitate and use it to improve academic and intellectual achievement of their students (Gay, 2000).

Chapter Summary

In this chapter, I tried to explore the ethno-geometry in traditional Paubha drawings. It was my immense pleasure to come up with some other hidden mathematical knowledge and ideas in Paubha drawings except geometry. I tried to talk about those mathematical ideas as well. I tried to discuss the possible answers for my principal research questions. I tried to explore the embedded geometrical ideas in paubha drawings by using interviews, field observations, and field notes as major research tools. For this I spent considerable time with my research participants.

CHAPTER V

FINDINGS, CONCLUSION AND RECOMMENDATION

Chapter Overview

This chapter comprises of the summary of my research findings. During the research period, I have encountered with abundant ethno-mathematical knowledge concealed in Newari Paubha drawings. As the purpose of my research is to explore the embedded ethno-geometry in Paubha drawings and incorporating them in lower secondary level school mathematics curriculum, I tried to explain that how it is possible to connect in this chapter. Besides this, in this chapter, I tried to show some of my suggestions and recommendations on involving ethno-mathematics in school classroom.

Retrospecting My Journey

The art and architecture of the Newari community has always fascinated me. I used to think "How these people can create such mesmerizing artifacts?" I believe all those who invested their time in making those things might not have attended any formal schooling since it has been an inseparable part of the Newari culture which dated thousands of year back. I always felt the essential study on Newari art and architecture seeing as those things is only possible by the wise utilization of the knowledge and skills that has been inherited by the ancestors. Art has been one of the major parts of interest for me. I choose to explore the mathematical knowledge concealed in newari traditional art 'Paubha' as my research field as I was sure that there are plenty of mathematical knowledge in those drawings which are out of our sight for long period of time.

I chose ethno-mathematics as my research field because I was going to study about the Paubha drawings of Newar culture. They have developed their own geometrical practices that can assist them in their day to day activities and other cultural practices. I think every cultural group is able to develop their own geometrical concepts and have also done in numerous ways. Through the bridge between the classroom pedagogies and approaches with the mathematical ideas and approaches found in traditional art can be set and they can be linked with each other (Rosa, 2000). Students can be explained how geometry has been a part of our daily activities. For this those geometrical knowledge are needed to link with classroom mathematics (Kathmandu University, 2008). As an individual belonging to the newar community, I felt it was the matter of great privilege for me to conduct research on my own cultural group.

I invested noticeable amount of time discussing about the geometrical practices in Paubha drawing with various Paubha artists who dedicated many years in their work. I chose some of the admired Paubha artist and I am glad they assisted me in every step and easily demonstrate the traditional ways to draw various geometrical figures. I caught the interviews in videos and collected sufficient field notes as a data for my research. Being familiar with different traditional approaches for drawing various geometrical figures unlike I have seen in classroom procedures are really rewarding for me. Besides this, I spent time capturing numerous photos during my time in research field which can be helpful in my research. I have gone through numerous papers on ethno-mathematics and ethno-geometry during my research period. Those papers helped me a lot in collecting valuable information about ethno-mathematics. I would like to express my heartfelt gratitude towards my research supervisor and other facilitators.

Exploring ethno-geometry in Paubha drawings was one part and as per my second research question, "How is the possibility to incorporate the "ethno-geometry" in the school curriculum?" I tried to answer both my research questions in previous chapter. While trying to link the ethno-geometry with the classroom pedagogies, I have search the possible ways to incorporate them in school curriculum. Concealed mathematical approaches in traditional Newari art can be taken as bit out dated, but interesting' (Hersh, 1993, p.14) way to perceive mathematical knowledge for the students. I found that my findings can contribute students to draw those figures differently rather than given the procedures in the books.

Although being very wealthy in art and architecture which demands high level of mathematical knowledge, the Newari Culture is not getting adequate attention. This research tried to provide the reason why it is important. It is not only about the incorporation of geometrical knowledge of Newari Community trying to make learning school level geometry more easier and fun, it's about the possibilities of socio-cultural and historical transformation of the society and desired reform in education system. For this reason, my ethno-mathematical purpose "is to retrieve and reshape school mathematics so that it is empowering for all peoples and also edifying for the human spirit of all" (Ernest, 2010, p. 82).

Findings of the study

It was the matter of great privilege for me to spend some prolific time studying about the traditional Newari art. Although it has got much spiritual and religious importance, I specially focused on the concept of geometry concealed in those drawings. My focus was on exploring those geometrical ideas embraced by the artists while drawing the paintings. While trying to address my first research question, "How newar inhabitants practice geometry in their traditional art", I was extremely delighted

to get familiar with various ethno-geometrical ideas that the Newari traditional art possess.

The technique of drawing straight line by using a rope and some flour or charcoal to color it seems effectual. During my teaching period, what I felt was there was the condition in which most of the students could only draw a straight line by using geometrical tools like ruler. While drawing in that way, I am sure my students will be able to ask that they can draw the boundaries for their football field by themselves.' It can help learning mathematics with fun. Similarly, the technique of drawing a circle may introduce them with the way to draw geometrical figure with fun. After explaining that technique of drawing a circle, they seems to having fun to draw a circle of the any size on any surface which their geometrical compass may fail to do. It is because the geometrical compass comes with fix size and students can only draw circle within the maximum reach of the compass. These both techniques are widely used in Newar community; specially drawing mandalas during special occasions like Newari new year and other occasions. In my own community, there is a trend of drawing mandalas in front of major temples and in some cases even competitions are organized. During the events, the figures are drawn considerably larger in size. Regardless of the size of the circle, the main principle or technique of circle can be taken as almost same like we do in our present classroom while teaching construction. It encourages the students to grab the logical part of constructing those circles.

Talking about the techniques of drawing squares and triangles, the incorporation of those methods discussed previous chapter may present the students with new ways to draw the figures while preserving the theoretical part at the same time. The method of drawing intersecting arcs from the opposite ends of the diameter

of the circle on its opposite sides depicts the similar concept of drawing a perpendicular bisector as prescribed by the text book. Same methods can be instructed to the students to use while drawing squares and rectangles with their geometrical tools. Besides this, the ways in which various artists prepare their own colors during Paubha drawings can be discussed with the students while explaining the concepts of ratio and proportion. While preparing the color in traditional ways; most of the time my mixing grinded color stones and other materials, due care must be taken since the wrong proportion may lead to the failure in creating the desired color. Similarly, the concept of golden ratio in Paubha drawing can be put in front of the students as an example that how our ancestors have been using the higher mathematics as well knowingly or unknowingly.

The incorporation of those traditional approaches of drawing various figures in mathematics is another crucial but yet very challenging task to do. As per my second research question "How is it possible to incorporate the "ethno-geometry" in the school curriculum?" and being a researcher it was my unavoidable task to do and I think that can be done in numerous ways. Students can be assigned in groups and asked them to prepare the best figure they can by using these various techniques could help students to avoid their fear of mathematics. But the facilitator should observe their work more carefully. Proper integration of the traditional approaches in teaching and learning mathematics can change the perspective to see mathematics as a culture free and pure body of knowledge (Luitel & Taylor, 2007) to culturally relevant body of knowledge. The concept of centre, radius, diameter and circumference can be explained to the students by drawing the circle in same way. '*Bataan*' can be taken inside the classroom as a tool to construct perpendicular line. Students can be explained how those artifacts are used by our ancestors to draw the geometrical figure

in the ways we have never thought about. I think, at least for some minutes, it will help the students to think differently keeping their books aside. We talk about the symmetry in our classroom repeatedly. By bringing some of the Paubha drawings, I believe we can give details not only about what symmetry is but also what is its importance in our culture and even in mathematical figures. During this moment, students can be instructed to find the symmetrical objects or figure around them to enhance their understandings.

Conclusions

Teaching and learning mathematics in conventional ways needs to be changed. The adaptation of same way of teaching mathematics; especially geometry may lead to unsuccessful and unworthy learning. Students will be bound to think in the way their teachers and books instruct which I truly believe is happening in Nepalese mathematics classroom. So there is immediate requirement of an alternative approach; more efficient approach and for this introduction and incorporation of ethno-mathematics can present with the new and productive substitute. I felt these things during my research period. Being loaded culture, art and architecture, for my research I tried to explore and incorporated embodied ethno-geometrical knowledge in traditional Newari art and I remained stunned to see how geometrical knowledge is concealed in traditional Newari art. Newari culture is indeed very rich in not only their culture, art and architecture but also possess plentiful mathematical knowledge at the same time. Those ideas in Newari the art exceeded my expectation in many ways.

I believe this study successful to bring ethno-geometry embedded in Newari art on surface. Besides this, it tried to present the ways to incorporate that knowledge in mathematics classroom. This study has focused on the contextualization of mathematics. It tried to advocate that the cultural incorporation in mathematics can

assist significantly in students' cognitive development. Nepalese classroom comprises of students from diverse cultural groups since Nepal itself is very rich in culture and tradition. Hence, through this we can expect proper addressing of all the students in the classroom belonging from various cultural and ethnic groups.

This study tried to provide teachers with the necessary reasons why cultural incorporation is vital in today's classroom for energetic involvement of students in learning mathematics. Through this research teachers are encouraged to use local materials to carry on their duty more effectively. Teachers must emphasize on making classroom pedagogy "inclusive" regardless of bringing any one of the cultural background of any student. Bringing local materials from various cultural groups can make the students from that specific cultural group feel empowered whereas the others will find alternative ways to acquire the geometrical knowledge; probably in more convenient way. It can further lead to the development of other teaching and learning materials by the students themselves.

What I believe is through the incorporation of cultural approaches in drawing various geometrical figure, we can develop an alternative algorithm in constructing those figures. It is not that by doing this we are ignoring the present procedure we have in our mathematics classroom. The main objective is to provide students an opportunity to get out the feeling that mathematics the combination of rigorous algorithms and procedure.

Implications of the Study

Exploring the embodied geometrical practices in traditional art and incorporation them in school level mathematics classroom is of immense value. In the present context where we can see many students are facing problems in learning geometry, even teachers themselves are struggling to put forward what they are trying

to say in front of their students. Hence, I believe this study could provide both students and teachers with trustworthy alternative by presenting the idea of ethno-mathematics.

The basic idea of ethno-mathematics is to bring cultural aspects in teaching and learning process. In mathematics classroom, student will get an opportunity to recognize the hidden mathematical potential of their culture. Students tend to find the learning more fun and attracted towards it when of their any cultural aspect is presented in the classroom. On one hand, students from the same cultural background get chance to relive their daily life and on the other hand, teacher himself will get an opportunity to get familiar with the cultural group. It is because the teacher may not be from the same cultural group and so needs to carry out enough study to bring it in the classroom. Similarly, the whole class will get an opportunity to '*think out of the box'* since the cultural approaches and knowledge are hardly included in the school level mathematics textbook.

This study tried to present the essentiality of the contextualization in mathematics teaching. Hence I strongly believe that it will act as an insight for the curriculum development committee for taking further vital steps in cultural incorporation for better curriculum. Similarly, it aimed to assist parents in recognizing the value of the culture or ethnicity they belong to. It tried to motivate them to gladly introduce their children with the local knowledge they posses for their better learning. Likewise, it provide them with the reason to respect their culture and take further step to preserve it with due heart.

For the community members, through this study, a mutual respect towards each others' religion and culture can be hoped. They can work together in preserving the knowledge left behind by their ancestors. Nepal is renowned for the diverse

culture it has in internationally. This study aimed to present the new reason why the country should be proud upon the multicultural diversity. The ethno-mathematics embedded in traditional Newari art can contribute equally to uplift the education sector of the entire nation.

Future Directions

During my research study I encountered many geometrical practices embedded in traditional Newari art; Paubha. I found the geometrical approaches adopted by the Newari traditional artists was simple yet reasonably distinct from the ways that we have been adopting in mathematics classroom pedagogy. For me those practices were very much convincing as well. Hence, I am looking forward to develop possible school geometry project to bring those ideas in mathematics classroom. I am planning to encourage my fellow teachers to provide adequate space for cultural practices regarding various mathematical ideas. To examine its effectiveness in geometry learning I will be studying the reflection of both students and teachers equally. Besides this, I have deep concern on carrying further research work regarding the use of newari artifacts and number system as well. I heartily hope my research work will guide and encourage other researchers to conduct research works on various cultural and ethnic groups of Nepal.

Recommendations

The study conducted in Newari traditional art on the quest of exploring hidden ethno-geometry had made familiar with numerous possibilities to standardize our mathematics learning approaches. During my research period the studied only about the traditional art of the Newar community and I end up in gathering plenty of ethno-geometrical knowledge and ideas embedded in those arts. After completion of my research I felt the necessity of similar research on other cultural aspects like local

games and farming system. My study only focuses on the exploring the geometrical part of lower secondary level only. Similar research can be conducted exploring secondary level mathematics and even higher mathematics.

There were several new research questions that frequently stroke my mind during the research period; for instance, 'How the geometrical knowledge is practiced in traditional pottery?', 'How Newari artifacts can be brought under pedagogical approach?', 'If there are interesting and yet useful geometrical knowledge in Newari traditional art in such noticeable amount, what about the other cultural groups in the entire nation?' All these questions lead me to the conclusion that there are copious geometrical as well as other mathematical approaches within the country that are yet to be explored. I could see mathematical knowledge about other topics of mathematics like height and distance and mensuration can be explored by conducting various researches on Newari architecture; studying about temples, inns, stupas and so on.

My research was mainly focused on exploring geometrical knowledge in Newari art. I would like to see same sort of research carried out on other the Newari artifacts in coming days. As I have expressed my opinion on enhancing the geometry learning through incorporation of ethno-geometry in mathematics classroom, would like to request the scholars from the curriculum development committee to provide sufficient space for cultural incorporation in mathematics curriculum. Similarly, I look forward to see the research conducted under the curriculum development board itself in future days.

Most of all I would like to request the teachers for bringing different local knowledge inside their classroom for better learning of their students. For that, they can start with exploring the mathematical knowledge concealed in their own culture.

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ANNEX

An activity plan for Incorporating Cultural Practices in Mathematics Classroom

Materials and Preparation

- A coil of rope or thread
- White power or Flour or charcoal power
- Scissors
- Wooden shaft
- Markers
- Color powder

Learning Objectives:

- Students will be able to draw various geometrical shapes (Straight line, Circle, Triangle, Square, Rectangle) without use of modern geometrical tools.
- Students will be able to observe the use of various geometrical shapes in cultural practices

Instruction:

- Display a picture of beautiful Mandala.
- Tell them that they are going to draw it by themselves.
- Introduce them with the materials they are using to draw the picture.
- Draw basic outline for the Mandala involving some students.

- Demonstrate every single step to construct various geometrical shapes by the traditional newari artists.

Independent Working Time:

- Divide the students in optimum group.
- Facilitate each group with the materials they are going to use to draw the picture.
- Instruct them to draw various geometrical shapes to prepare a model of Mandala in provided space.
- Encourage them to use every possible geometrical shape in their picture.
- Encourage them to think about other possible local materials besides what they were provided that can be used to draw the picture.
- Instruct the students to complete the picture by filling various color of their choice.

Review and Closing:

- Review each group's picture and appreciate their effort.
- Ask the students whether they like to do similar activities in coming days. This will give a sense of whether they enjoyed the activity.
- Ask the students to compare the method of construction of those geometrical figures with what they have learned while drawing Mandala.
- Ask the students if they have similar cultural practices.
- Encourage the students to bring those practices in classroom.