EXPLORING MATHEMATICAL KNOWLEDGE AND PRACTICES EMBEDDED IN TRADITIONAL NEWARI OIL MILLS: AN ETHNOGRAPHIC STUDY

Sanjeev Maharjan

A Dissertation

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DECLARATION

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

August 18, 2021

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Sanjeev Maharjan

Degree Candidate

DEDICATION

This research work is dedicated to …

Mr. Deepak Maharjan, my friend who supported me financially to complete my degree.

My parents had always guided and supported me in my education.

My wife who had always inspired me to complete this research. She was always there with me during the whole process of this research.

My son whose presence always inspired me to complete my degree education.

Master of Education in Mathematics, dissertation of *Sanjeev Maharjan* entitled *Exploring Mathematical Ideas and Concepts Embedded in Traditional Newari Oil Mills: An Ethnographic Study* was presented at school of Education, Kathmandu University on August 18, 2021

APPROVED

_____ August 18, 2021

Mr. Indra Mani Shrestha
Dissertation Supervisor
Lecturer, Department of STEAM Education

_____ August 18, 2021

Ms. Tara Paudel
External Examiner

_____ August 18, 2021

Asst. Prof. Binod Prasad Pant
Acting Head, Department of STEAM Education

_____ August 18, 2021

Prof. Mahesh Nath Parajuli, PhD
Dean/Chair of Research Committee

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.

_____ August 18, 2021

Sanjeev Maharjan
Degree Candidate

ABSTRACT

An abstract of the dissertation of *Sanjeev Maharjan* for the degree of *Master in Mathematics Education* presented at School of Education, Kathmandu University on August 18, 2021.

Title: *Exploring Mathematical Ideas and Concepts Embedded in Traditional Newari Oil Mills: An Ethnographic Study*

Abstract Approved: _____

Mr. Indra Mani Shrestha

Dissertation Supervisor

We live in a world that is dominated by math-based technology. But most students feel that they cannot do mathematics and they start to hate mathematics. Instead of encouraging fear of mathematics education in students' minds, mathematics education should adopt a greater understanding of how mathematics is applied in our daily life and how it is embedded in our culture. As their curiosity in mathematics raises, they will be in the position to see that mathematics is extended elsewhere in the classroom, that it has importance in their day-to-day life and their culture.

In the context of Nepal, mathematical classroom belongs students from diverse cultural and ethnic groups and hence I felt the necessity to conduct a research study on mathematical integration in a culture that we practice. For this I chose to conduct research on the Newari community with my major research questions; "What mathematical knowledge and practices are embedded in traditional Newari oil mills?"

and “How can school mathematics be contextualized through mathematical knowledge and practices embedded in the traditional Newari oil mills?”

My research study was guided by a qualitative ethnographic research design. During my field visit, observation and interview with my research participants, I encountered many mathematical practices embedded in traditional oil mills which are simple to understand but not used in our present teaching and learning pedagogy. Instead of using a board and marker for teaching mathematics, allowing students to visit places outside the classroom and observing cultural mathematics in cultural places can be one of the effective ways of teaching mathematics. By doing so, students will find the uses of mathematics in their daily life and will get an interest in mathematics. Therefore, the incorporation of ethnomathematics in mathematics classrooms will give positive change in teaching and learning mathematics. The literature review in my research study supported me to develop my conceptual understanding of related terms that supported me in developing this research work.

Research participants were not well educated. They never learnt the process of construction of oil mills in any educational institute. They said that they were not educated enough to directly link the working process of oil mills to mathematics but nowadays they had realized that there are many non/mathematical pieces of knowledge embedded in it. So, they had tried their best to answer my question and tried their best to help me to find my research conclusion.

I presented mathematical knowledge and practices embedded in traditional oil mills and possible ways to incorporate them in teaching school mathematics through ethnomodeling. My research will be helpful for mathematics teachers, students, and curriculum experts to integrate ethnomathematics in a mathematics classroom.

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Sanjeev Maharjan
Degree Candidate

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ABBREVIATIONS

B. S.	:	Bikram Sambat
CBS	:	Central Bureau of Statistics
CDC	:	Curriculum Development Centre
CRP	:	Culturally Relevant Pedagogy
ERO	:	Education Review Office
FoK	:	Funds of Knowledge
K.U.	:	Kathmandu University
LSA	:	Lateral Surface Area
M. Ed.	:	Master of Education
OCE	:	Office of the Controller of Examinations, Sanothimi
SEE	:	Secondary Education Examination
SLC	:	School Leaving Certificate
T.U.	:	Tribhuvan University
TSA	:	Total Surface Area
UNESCO	:	United Nations Educational, Scientific and Cultural Organization
VDC	:	Village Development Committee

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CHAPTER I

INTRODUCTION

Background

Education is considered the most powerful tool to change and move forward in the world. Education is considered as one of the basic needs of human beings as it is one of the most essential factors to live our lives smoothly. Education does not only help in personal and professional development, but it also helps in the cultivation of human civilization. So, in order to make a child ready for the future, education is the most effective and powerful tool.

Mathematics is a subject that is developed as per human necessity. The development of natural numbers like 1, 2, 3, … is most likely an immediate consequence of their need (Knott, 1979). Moreover, Mathematics as a subject is developed based on our daily life activities and the cultural practices of human beings. According to the report published by the Controller of Examinations (2011), the highest number of students failed in mathematics in the School Level Certificate (SLC) examination in 2010. About 64,517 students failed in mathematics which is the highest number of as compared to the other subjects. In my view, this result shows that the curriculum in Nepal is not well contextualized with the cultural practices of Nepal. If it had been well contextualized, students would have not been suffered that much in mathematics. Therefore, mathematics is a context-dependent subject related to daily life activities. If our curriculum could link school mathematics with the activities that the students do daily in their cultures, there would not be the highest failure rate in mathematics in school education. In this context, I mainly focused on

how cultural mathematical practices could be incorporated into school mathematics so that students would be able to learn mathematics meaningfully. For this, being from the Newari community, I selected the Newari traditional oil mills in the Lalitpur district and explored mathematical knowledge and practices in them so that I could explore ways of incorporating them into school mathematics from the ethnomathematical perspectives. Barton (1996) stated that ethnomathematics is a program that investigate the ways in which different cultural groups comprehend, articulate, and apply concepts and practices that can be identified as mathematical practices. If we could relate the school mathematics with our culture, then it might be helpful for students to understand mathematics. For example, while teaching pyramid in classroom, before we start teaching if we take students to visit nearby temples and ask them to locate the different shapes in the temple. They can notice the different shapes in temple and can find the mathematical aspects that they read in school mathematics. Doing so, students can easily understand the solution for the problem for any kind of questions.

Mathematics can be observed in our everyday life. We practice mathematics from early morning until we sleep, that is, the whole day. Every day we brush our teeth, wash our faces and perform other many activities in our daily life but many of us are unaware of the mathematics that we use in doing such daily activities. For example, we use a certain amount of toothpaste, water, etc.; we apply our force using some amount of energy; we move, walk, run; we drink water, milk; we eat fruits, food, etc. Sometimes I share the essence of mathematics with my friends and students that if there had not been mathematics developed from the stone age, we would not have been able to solve various real-world problems easily and the people across the world would have been living their hard lives as in the stone age. Moreover,

mathematics has helped us to think and act analytically and logically and hence, we are now able to develop our problem-solving skills. The science behind mathematics has been the pillar of knowledge and skills that are required to live our lives easier and happier than the lives our ancestors experienced. Because of mathematics, people where able to discover or invent many scientific and mechanistic tools that have been helping us solve real-world problems from simple to complex ones. Not only on the earth, even we are now able to understand how the heavenly bodies in the universe keep revolving and rotating on their paths because of their gravitational forces. Therefore, all human beings need to have mathematical knowledge and skills to run their everyday activities skillfully. According to D'Ambrosio (1990), the search for solution for specific problems that help the development of mathematics are always imbedded in a cultural context: in order to understand how mathematics is created, it is necessary to understand the problems that precipitate it. It is needed to understand those problems by bearing in mind the cultural context that motivations them.

The history of human civilization is the greatest evidence for the existence of mathematics in our daily practices. Mathematics was not there already made; it was developed gradually based on the practices of human civilization for a long time and is incorporated in school mathematics. However, over time, mathematics became famous for its abstractness instead of its connection with cultural mathematics practices. For example, I learned various abstract formulae, laws, axioms, postulates and theorems in mathematics. However, I never learned how they were connected with my day-to-day activities. I am originally from the Newari community, and I was grown with various Newari cultural mathematical practices though my community is now mixed up with various communities. I never learned how my cultural mathematics could be a source of mathematical knowledge. If I had been able to learn

it, it would have been much easier to learn mathematics for me and my learning would have been meaningful for me. I know very well that mathematical education helps us use mathematics in our daily life activities in a wise way. I have realized now that we can construct a standard measuring scale with the help of a normal scale used by students in learning school mathematics. Moreover, that constructed scale can help us make measurement easy in our life. We have been using our different cultural measurement systems. Therefore, these constructed measuring scales can help us carry those measuring easy. Ethnomathematics may be described as a way in which people form a particular culture use mathematical knowledge and practices for dealing with quantitative, relational and spatial aspects of their lives (Borba, 1997). This method of observing mathematics confirms all people's understanding of mathematics because it exhibits that mathematical thinking is essential to their lives.

I completed my school level education at one of the government schools in my community. My school was located in a mixed community. Students from different caste were there in my class. However, most of the students and teachers were from the Newari community. In my schooling time, I had barely seen any teacher bringing cultural aspects while teaching. Teachers used to teach only that what was written in the textbook. Even social studies teachers did not give any social examples while teaching social studies. The teacher would use only the examples and exercises given in the textbook. My school was a community school. Therefore, there were no well-qualified and experienced teachers at that time who could use locally available material as teaching learning material and could give live examples related to use of mathematics in our daily life. In the context of mathematics, we did not have any cultural examples in my classroom. Rote learning and memorizing the formulae, laws, rules, algorithms, solutions and answers to the questions, etc. were the only ways to

learn mathematics. I had no idea why I was learning mathematics and how it is applicable in my life. Even teachers, school management, my parents had never shown us any connections between textbooks and our daily life activities.

I recall now those days when I was in grade one and had to memorize the multiplication tables. I still remember how rudely my teacher gave me physical punishment for not memorizing the multiplication table of '2' i.e., 2, 4, 6, 8, 10, 12, 14, 16, 18, 20. Not only me, but all the students who could not memorize multiplication tables would also get severe physical punishments. The teacher never gave us ideas about how to understand the tables of multiplication and why we needed to learn them. He would just write the multiplication tables on the blackboard and ordered us to memorize them. I would memorize them day and night at home but could not insert them into my mind. Whatever I could memorize at home were also erased when the teacher would ask to chant them. Maybe, I was afraid of the teacher or I had no conceptual knowledge and understanding of multiplication tables. According to Hiebert (1986), conceptual knowledge is characterized most clearly as knowledge that is rich in relationships. "It can be thought of as a connected web of knowledge, a network in which the linking relationships are as prominent as the discrete pieces of information. Relationships pervaded the individual facts and propositions so that all pieces of information are linked to some network" (pp. 3-4). Moreover, not only the case of multiplication tables, I mostly spent my schooling in learning procedural knowledge of mathematics using rote-memorization and algorithmic problem-solving knowledge and skills.

A procedure is a chain of steps, or actions, done to complete a goal. Knowledge of procedures is often termed procedural knowledge (Canobi, 2009; Rittle-Johnson et al., 2001). Like me, no students could make the connection between

school mathematics (and education) with their daily life activities. There was a purely theoretical way that teachers would use to teach mathematics and all other subjects in school. They did not make any connections between mathematics and daily life activities like playing, cooking, cultural activities etc.

Today, as a Master's degree student in KU, I see there is adequate space for the cultural practices that we are following in our society, family, school, as well as school curriculum. As we all know that Nepal is a diverse South-Asian country with at least 125 ethnic/caste groups, more than 10 religious groups, and more than 123 mother tongue languages are spoken in Nepal (Central Bureau of Statistics [CBS], 2011). Because of its diversity, it is rich in different cultural aspects but we are still failing to utilize our cultural mathematical resources for teaching and learning mathematics. We can see around us that many foreigners come to Nepal to enjoy the traditional and cultural places. There is a great role of tourism in the economic development of Nepal. Our culture and practices have a very important impact on tourism and economic developments. Also in our culture and the cultural activities, cultural workstation, cultural play ground etc. is rich in mathematical knowledge. In this regard, it's time to explore the mathematical knowledge and practices that we use in our cultural practices in our diverse communities so that students can learn school mathematics in the way that the community people are practicing in their cultures. So, I realized that it is essential to explore such mathematical practices by incorporating culture, daily life activities, and other different cultural artefacts. By doing so, I think that students can learn and understand mathematics in a better and meaningful way. For this, we can use ethnomathematical perspectives in teaching and learning school mathematics. Rosa and Orey (2015) stressed that the introduction of Ethno-

mathematics can enhance the students' learning and knowledge by taking their socio-cultural.

In the present mathematics curriculum in Nepal, 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) which was taken for the idea of knowledge to represents the view that mathematics is a collection of already finished knowledge waiting to be transmitted to students (Lerman, 1990). In the context of Nepal, teachers, students, parents think that mathematics is a rigid subject, the world of mathematics is whatever teacher shows to students. There is no role of students in generating mathematical knowledge. Students just receive the knowledge whatever the teacher gives. Therefore, in my view, mathematics is one of the most difficult subjects in the education system of Nepal. Till today, whatever we have learned and taught in school mathematics are purely western because they are directly brought from abroad and incorporated into the curriculum without contextualization. Only a few of them are rarely practiced in Nepali contexts. That's why, students feel mathematics is one of the difficult and abstract subjects.

Discussing the local cultural practices, I remember my school days when I would play a game named '*chungi'* where I learned multiples of 2 by the play-way method which was strange but true. The *chungi* is made up of rubber bands that are tied together forming a bunch. While playing the game, the bunch of rubber bands called *chungi* is continuously thrown up in the air with one leg and the number of times it is thrown is counted until it is fallen on the earth. The person who can throw the *chungi* the maximum number of times wins the game. I still remember that we would throw it more than a hundred times to win the game. Even it would sometimes

reach more than two hundred times to win the game. While playing the game, if a person drops the rubber bunch on the ground, the turn of another player comes. This goes on for all the players participating in the game. Finally, the top scorer wins the game. So, during the game, we need to remember the number of times the *chungi* is thrown by each player. To make counting easy to remember, I would count one for two throws successively such as 2, 4 6, 8, ... Now I realized that this was how the multiplication table of 2 could be learned. However, such practices were not discussed in the classroom by any teachers. But I still remember teachers discouraging students to play the *chungi* because they would tell us that playing the *chungi* was just a waste of time and they had confiscated my *chungi* many times and gave punishments as rewards. However, if my teachers had used such cultural practices in learning counting numbers and multiplication tables, I along with my friends would not have had any difficulties in learning mathematics meaningfully. Rather, we would have learned mathematics happily and enthusiastically.

In my childhood, I was not aware of the fact that while playing the game I was learning the multiples of 2. But now I realized that I was unknowingly learning the multiplication table of 2 and it made me easy and fast in learning and solving the problems of multiplication and division of 2. Moreover, learning mathematics can be fun and interesting if a teacher could connect mathematics with the games or any cultural practices that students do in their daily activities. However, our Nepali school mathematics education is culturally decontextualized because of which teachers (and students) are compelled to follow the mathematical knowledge and practices borrowed from foreign lands (Luitel, 2009, 2013; Pant 2015; Shrestha, 2018, 2019). Due to this, students are bound to solve the routine problems of decontextualized textbooks so that they are prevented from learning problem-solving skills. As a result,

they are not able to solve real-world problems. Moreover, when I went through various local research studies on the cultural contextualization of mathematics education, e.g., Luitel (2009, 2013), Pant (2015), Shrestha (2018, 2019), etc., I understood that the concept of contextualization of mathematics arises with the concept of ethnomathematics. According to D'Ambrosiso (1985), mathematics is practiced among the community or group of people in national tribe society, labor groups, children of a certain age and professional classes. Ethnomathematics is mainly concerned with socio-cultural aspects and mathematics. Contextualization in teaching mathematics escaping from the conventional way of teaching by linking the pedagogy with the local context can be aimed from ethnomathematics (Jablonka & Gellert, 2007). Ethno-mathematics can motivate the students to know the im/pure nature of mathematics (Luitel, 2013). The mathematical functions present in our different cultural practices are not considered mathematics. They are just a culture. Only pure mathematics is authentic mathematics and all other forms such as embodied, art factual, informal, ethnic, and indigenous are not genuinely mathematics (Gilsdorf, 2012).

Despite experiencing culturally decontextualized learning in my childhood schooling, I had my own experience of having fun while learning mathematics from the perspectives of cultural contextualization of mathematics in the latter part of my schooling. I remember the day when I was in grade X. Moreover, my school is located nearby a local temple. One day, our mathematics teacher took all the students to visit the temple first before teaching the chapter "mensuration". We all students were asked to observe the top of the temple which is in a pyramid shape. I got a different perspective of analyzing the shape of the pyramid when the shape was in front of me and so on the other shapes such as cylindrical, conical, spherical, semispherical

shapes, etc. I don't remember my mathematics teacher orienting all the students on contextualization of mathematics, but now, I have realized that the teacher, maybe knowingly or unknowingly, has tried his best to culturally contextualize school mathematics by taking all the students to observe the local temple. Moreover, if students are taken to visit such cultural places, they can explore many mathematical ideas embedded in cultural practices, artifacts, etc. and enrich their mathematical knowledge embedded in them (D′Ambrosio, 2001). I found that there is an eminent role of mathematics teachers to bring mathematical knowledge and practices in the classroom embedded in students' cultural practices to empower them from the perspectives of culturally contextualized mathematics education.

Above all, the main purpose of selecting this topic for my research study was that after joining my master's study at Kathmandu University, I gradually realized that mathematics is concerned with not only solving routine problems of textbooks rather it is about solving real-world problems that we encounter in our daily life. As I was born in a Newar family in the Lalitpur district, my community is rich in traditional cultural rituals and I have experienced and practiced many cultural practices. While practicing these all-traditional cultural practices, I was unable to understand what I was doing. I just followed them because my parents and grandparents have been following the same for ages. That's why; I was encouraged to select the research topic related to my cultural practices and hence after discussing with the dissertation supervisor I came up with the research topic "*Exploring mathematical knowledge and practices embedded in traditional Newari oil mills: An ethnographic inquiry*". Moreover, it didn't happen at once. When I showed my interest in cultural mathematics, the supervisor suggested me exploring the typical cultural practices of the Newari community which I have been experiencing

throughout my life. For this, I explored various Newari cultures and visited different cultural places such as temples, oil mills, etc. and shared with him. Finally, my supervisor suggested conducting my research study on the traditional Newari oil mills as the research study on traditional oil mills is hardly found in the field of educational research.

Learning mathematics can be made better and easier if teaching mathematics is contextualized. The concept of contextualizing mathematics has arisen with the concept of ethnomathematics. Mathematics is practiced among the community or group of people in national tribe society, labor groups, children of certain ages and professional classes (D'Ambrosio, 1985). Therefore, ethnomathematics is mainly concerned with socio-cultural aspects and mathematics. Whatever definitions of any mathematical terms we learn, most of them is taken directly from western cultural practices without making any reform or change in them. However, whatever mathematical knowledge and practices we borrow from western culture are not unique to us. Even we Nepalese have been practicing such mathematics in our daily life in our own cultural ways ever since mathematics was incorporated as a subject or discipline in formal school education. While teaching different geometrical shapes and its property, we can use locally culturally available materials like in the case of a circle, we can take *roti, chura* etc. to understand the concept of different terms in a circle. Similarly, there are other different cultural things that can relate to other geometrical shapes.

Kathmandu valley has been enlisted in UNESCO's World Heritage Sites as there are many historically and culturally crafted temples and cultural places (Ministry of Culture, Tourism and Civil Aviation). Most of these artifacts are crafted by the Newari people. There is no doubt that these culturally crafted artifacts that

attract thousands of tourists every year have used much mathematical knowledge, mostly the knowledge and practices of geometry. Besides heritage sites, other different Newari activities are also enriched with such mathematical knowledge and practices. One of them is the Newari traditional oil mills in which we can explore many mathematical knowledge and practices such as geometrical shapes, measurement systems, etc. These oil mills are popular in the Newari community for more than 500 years and are widely used by Newars for extracting oils from mustard seeds. The oil extracted from such traditional oil mills is popular at Kathmandu valley and we have also been using this oil in our kitchen at home.

Since my research study was based on ethnography as a research methodology, I came to know from the Cambridge Learner's Dictionary (2019), ethnography is a scientific description of the culture of a society by someone who has lived in it. Based on this preliminary understanding of ethnography, I realized that I am also a part of my Newari community in which I spent my childhood to date. Why not I should explore my cultural practices from ethnomathematical perspectives so that I could find the possibility of connecting school mathematics with cultural mathematics through the contextualization of mathematics education. In this regard, not only Newari cultural practices, many other cultural practices across the country can be explored and find out the possibilities of integrating them in conventional mathematics education and this research study may be one of them that contributes to the cultural contextualization of teaching and learning of mathematics.

As I was born in a Newari family, I have been following many Newari cultures since then. Before I joined Kathmandu University (KU), I would think that all cultural practices were just the ideas, customs, and social behaviour of a particular

people or society but now in the present time, as I am a master's student, I realized that my cultural practices are one of the biggest sources of mathematical knowledge.

As Nepal is rich in different cultures, there should be given adequate space in the mathematics curriculum for the multiple mathematical cultural practices. The introduction of ethnomathematics can enhance the students' learning and knowledge by taking their socio-cultural activities into account (Rosa & Orey, 2015). I could sense the possibilities of exploring mathematical knowledge from the diverse cultures of students. Moreover, traditional teaching in school involves teacher-centered approaches dominated by abstract concepts, theoretical lessons and chalk-and-talk methods. In this context, according to Reyes et al. (2019), contextualization is another way of addressing the content of activities undertaken in the mathematics classroom that motivates the learners to know, understand, and appreciate the cultural heritage. In this regard, I also had an experience of getting motivated in learning the problems from the chapter "Time and Work" when my teacher would link the textbook problems with real-life problems.

In present context, mathematics is taught without using teaching materials, just focusing in the product. Students need to memorize the solutions along with all the formula and most teachers do not relate mathematics with cultural activities. Through my research, I have attempted to explore the mathematical practices and knowledge in traditional Newari oil mill and how ethnomathematics incorporate such mathematics in school mathematics.

Rationale of Study

As an M.Ed. student in KU, I came to understand that there is a significant role of Ethnomathematics to uplift the standard in learning mathematics. 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). Newari culture and tradition are one of the ways to for making the connection between the local and cultural activities of students with the curriculum in Nepal. When I was learning mathematics in school, I always used to hear that mathematical is an abstract subject and need more time and concentration to get better marks and there is a belief that if a student is bright in mathematics, he/she is automatically good in other subjects. However, I found that mathematics is quite easier subject because most of the time while doing mathematical problems, I used to imagine a condition where I am facing the problem in my daily life. I will imagine the possible activities that I will do for the solution of the problem and do the same for solving the problem in the mathematical classroom. For example, while doing almost all problems in time and work chapter, I always imagine the given condition and feel it as I am doing it in daily practice and solve the problem. Maybe that is why I did not realize time and work as a difficult chapter whereas my friends find that very difficult. They usually didn't try solving the problem. I found mathematics as an easier subject when I relate mathematics with daily life activities. Similarly, I think that mathematics will be easier subject if we as teachers can interlink mathematics with the daily activities that we do. One of the good activities is our cultural practices because we all follow our cultural practices in our everyday life.

Another unavoidable aspect of cultural practices in learning mathematics in the classroom is that there are students from different cultures. In the classroom, students can exchange their cultural practices with each other. So, there is a high possibility that most of the students can be familiar with and learned about multiple cultures. During teaching in the classroom, I feel that there is less participation of

students in the mathematics classroom. Therefore, by incorporating cultural practices in mathematics education, students will increase their active participation in classroom activities. In my research context, I have faith that traditional Newari cultures comprise various aspects of mathematical knowledge and practices and in the case of traditional Newari oil mills, we can find the different geometrical aspects in its construction and different typical measurement systems in measuring oil. Moreover, specific contexts (Barton, 1996). When students finds mathematics in their culture, they can see the use of mathematics and doing so, teaching learning activity will be easy and more effective.

Problem Statement

After I appeared in SLC examinations in 2062 B. S. (2005), there was around a three-month gap before I joined my higher education. That was my free time. So, I decided to guide some students in learning mathematics in the same school where I studied. As the majority of students were from the Newari community, only five Newar students from grade nine were interested in extra math support. They came to my home and I started guiding them for one hour per day. At the beginning of the study, I found them lost somewhere; they were not grasping the things of mathematics that I was trying to teach them. After few days of analysis, I realized that they have some language problems. Then just for a try, I changed the communication language from Nepali to Newari and their progress in mathematics was unbelievable. They were able to build mathematical concepts and later, they performed better in exams and the classroom too. During this time, I realized that first they understood mathematics in their native language and then in other languages.

The existing school mathematics 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). Our curriculum is not well contextualized, we are focusing on globalized mathematic education. As per the report of the Office of the Controller of Examinations (OCE) (2014), 29.62% of failed students failed in mathematics in 2067 B.S. Similarly 38.79% and 42.09% failed in 2068 B.S. and 2069 B.S. respectively. The fail rate of students in mathematics is increasing every year. In my view, this poor result is due to the globalized school education in Nepal and so is the curriculum. But due to different problems such as language, decontextualized curriculum, pedagogy and assessment, it seems that the students cannot develop the knowledge and skills of mathematics that are essential for solving real-world problems and as a result, they cannot prepare themselves for the globalized mathematics education. So, until we first contextualize mathematics with the local cultural ideas, many students will not be able to understand the globalized mathematic education. Though it is a challenging task to teach mathematics by connecting it with the cultures of students, I am sure with the proper plan and enough authority to the teachers, it will be effective and the students will learn mathematics and at the same time, they are preserving their culture too.

Above all, culturally decontextualized mathematics education has become a serious and pertinent issue in the context of Nepal. I don't mean to claim that the reforms have not been made in the mathematics curriculum. Yet, the school mathematics curricula have incorporated many contextual problems. Nevertheless, it seems insufficient to regulate classroom teaching from the perspectives of culturally contextualised mathematics education. The National Assessment of Student Achievement in Mathematics conducted by the Education Review Office [ERO] (2018) has also indicated that the student achievement in mathematics across the nation is decreasing instead of increasing. In the same way, in the School Leaving

Certificate (SLC) examination, now Secondary Education Examination (SEE), the pass rate in mathematics is always more or less 50%, which is far less compared to other subjects. This shows that students have very little interest in learning mathematics. Therefore, this issue needs to be solved and hence I felt a necessity to find the possible ways of resolving such serious issues so that we can motivate students to learn mathematics meaningfully. In this regard, to find the possible ways of resolving such issues, I selected the cultural contextualization of mathematics education. For this, I explored various mathematical knowledge and practices embedded in traditional Newari oil mills and further explored various ways of contextualizing school mathematics through mathematical knowledge and practices embedded in the traditional Newari oil mills.

Purpose of the Study

The main purpose of this study is to explore mathematical knowledge and practices in traditional Newari oil mills in Newari community. Furthermore, I also explored the possible ways of contextualizing school mathematics through such mathematical knowledge and practices embedded in the traditional Newari oil mills.

Research Questions

I generated two research questions as follows:

- What mathematical knowledge and practices are embedded in traditional Newari oil mills?
- How can school mathematics be contextualized through mathematical knowledge and practices embedded in the traditional Newari oil mills?

Delimitation of the Study

The objective of my study was to extract the mathematical practices in Newari culture, especially the geometrical shapes used in the construction and operation of

traditional oil mills. I explored ethnomathematical knowledge from the Newari cultural practices and geometrical shapes of oil mills as well as other possible mathematical ideas such as measurement systems, etc. by consulting the local Newar people and scholars. For this study, I visited Newar inhabited places Khokana and Badegaun of the Lalitpur district. Therefore, my research study was limited to the study of traditional Newari oil mills located in these two places of the Lalitpur district. My focus was to study mathematical practices in Newari culture and traditional Newari oil mills and ways of implementing my findings in teaching and learning school mathematics.

Significance of the Study

Although we live in a society that is dominated by math-based technology, most people typically only think about school math when they think about mathematics and most students hate mathematics as they think mathematics is one of the most difficult subjects or they feel that they cannot do mathematics as it is defined by the traditional academic approach (Mukhopadhay et al., 2012). Wolfarm (2010) suggested that the future technology-based math should probably not even be called "Mathematics" due to its negative connotations and the potential changes to the curricula and pedagogy. As an alternative to implanting fear and hate about mathematics to students, we should show how mathematics is applied in our increasing technology, in our society, in our culture. School mathematics needs to expand its parameter and become inclusive of mathematics found in the community where students live. One way to do so is to include the aspects of ethnomathematics, culturally-based mathematics to help students and grab greater interest in mathematics. As their interest grows towards mathematics, they will have a better

vision about mathematics which can go beyond the four walls of a classroom and find the relationship with their culture and others' culture.

Chapter Summary

In this chapter, I intended to put forward my understanding of the cultural nature of mathematics. We have been teaching mathematics as a rigid subject, culture-free subject, but I found it crucial to bring cultural aspects and traditional background inside mathematics for fruitful learning. To provide proper insight for this, I have brought my past experiences both as a mathematics teacher and as a student. I tried to explain the reasons for choosing Newari traditional oil mill as my research topic and the necessity of exploring mathematical knowledge hidden in its different parts. For that, I chose my research questions to conduct my research in a systematic way.

CHAPTER II

LITERATURE REVIEW

Chapter Overview

Reviewing the literature means 'locating summaries, books, journals, and indexed publications on a topic; selectively choosing which literature to include in your review; and then summarizing the literature in a written report' (Creswell, 2012, p. 9). In this regard, I reviewed various literatures relevant to my research study under the themes – Thematic Review, Theoretical Review and Empirical Review. In the thematic review, I have reviewed different themes relevant to my research study. In the theoretical review, I reviewed two theories, namely, Vygotsky's Social Learning Theory and Habermas' Knowledge-Constitutive Interests. Finally, in the empirical review, I reviewed the previous research studies relevant to my research study and discussed the research gap between the reviewed literatures and my research study.

Thematic Review

This topic describes the major themes or ideas of my research study. I selected the themes based on mathematical knowledge and practices embedded in cultural practices and contexts as my research study was based on exploring mathematical knowledge and practices embedded in Newari culture and traditional Newari oil mills. Moreover, in a thematic review of the literature, the researcher identifies different themes and discusses only the major ideas or results from studies rather than the detail of any single study (Creswell, 2012). According to Killen (2003), when students think about the knowledge that got and try to relate it in their daily life activities then they understand the actual mathematics. Therefore, I deeply engaged myself in

understanding relevant themes that could contribute to carrying out my research study. I reviewed five themes – *ethnomathematics, culturally relevant pedagogy, contextualization of mathematics education, ethnomodeling, and mathematical knowledge and practices,*

Ethnomathematics

The term ethnomathematics was originally coined by D'Ambrosio (1985) and defines ethnomathematics in the following way:

> The prefix ethno is today accepted as a very broad term that refers to the social-cultural context and therefore includes language, jargon, and codes of behavior, myths, and symbols. The derivation of mathema is difficult, but tends to mean to explain, to know, to understand, and to do activities such as ciphering, measuring, classifying, inferring, and modeling. The suffix tics is derived from techné, and has the same root as technique. (p. 81)

When a group of people work together to find the solution of mathematical problem which they face in their daily life, that solution has been called ethno-mathematics (Munetsi, 1995). D'Ambrosio (1985) had described ethno-mathematics as, mathematics which is practiced among distinguishable cultural groups, such as national-tribal societies, labor groups, children of a certain age bracket, professional classes and other group of people. In my research, I have also presented the mathematical practices practiced by a group of people in Khokana in running an oil mill. Gerdes (1988b, as quoted in Frankenstein, 1990) states mathematics as the union of all ethno-mathematics practiced in different group of people. Gerdes (1994) outlines many concepts which form the basis of ethno-mathematics including indigenous mathematics, all provide analysis which locate mathematics as cultural practices. According to Rosa & Gavarrete (2017), "Ethnomathematics is connected

with the pursuit of peace, the challenge that many communities and school systems face today is in determining how to shape a new open, modern, international culture, which integrates and respects western science" (p.8). School students are having problem with mathematics as they could not find any use of mathematics in their daily life activities, so relating cultural mathematics in classroom teaching and learning activities, students might find the uses of mathematics. This also includes an increased cultural ethnic, and racial diversity. In this respect, D'Ambrosio (2009) states that:

> Education is a practice present in every culturally identified group. The major aims of education are to convey to new generations the shared knowledge and behavior and supporting values of the group, and, at the same time, to stimulate and enhance creativity and progress. (p. 242)

Nepal is a country where classrooms are crowded with multicultural and multilingual in general because, in most schools of Nepal, students come to school from different cultures and linguistic backgrounds. I have experienced the same condition at each level of school education, where classrooms are full of diverse students from diverse cultures and communities. Even nowadays, in almost every class of a school where I am working as a mathematics teacher, I have found that the students are from different cultures – among them are locals as well as migrants of different ethnicities, castes, genders, races, etc. In this context, Gates (2006) also expressed that "In many parts of the world, mathematics teachers are facing the challenges of teaching in a multi-ethnic and multi-lingual classroom containing immigrant, indigenous, migrant, and refugee children" (p. 391). So, it has been a challenge for both the teachers as well as students in teaching and learning mathematics in a comfortable way. Thus, by Gerdes (1989a), ethno-mathematics is a movement. It is an dynamic repossessing of a mathematics points of view as part of

indigenous culture. This comprises producing new mathematics from traditional sources and conventional mathematics. The oil mill was constructed by the people who have never been any kind of educational institution for their education. They constructed it just to solve the problem of expelling oil but now we can see the different mathematical ideas used in its construction. Ascher (1986), defines ethnomathematics as the study of mathematical ideas of non-literate peoples She sees these mathematical ideas as models, structures and patterns which can be manipulated and discussed in the abstract. It is necessary to understand the patterns or structures that we follow to carry out our daily life activities and the approaches to learning mathematics.

D'Ambrosio (1993) stated that the mission of the ethnomathematics program is to acknowledge that there are different ways of doing mathematics by considering the appropriation of the academic mathematical knowledge developed by different sectors of the society as well as by considering different modes in which different cultures negotiate their mathematical practices. Barton (1996) stated that in this conception, ethnomathematics is a program that investigates how different cultural groups comprehend, articulate, and apply concepts and practices that can be identified as mathematical practices.

Similarly, ethnomathematics may be described as a way in which people from a particular culture use mathematical knowledge and practices for dealing with quantitative, relational, and spatial aspects of their lives (Borba, 1997). This way of viewing mathematics helps to increase the participation of many people's thinking inherent to their lives. Further evidence of this view is given by Orey (2000), who stated, "The paradigm that diverse cultures use or work within evolves out of unique interactions between their language, culture and environment" (p. 248). Within this

context, D'Ambrosio (2006) presented his argument that in a mathematical perspective, mathematical thinking is developed in different cultures in accordance with common problems that are encountered within a cultural context.

The Curriculum Development Centre (CDC), Nepal also prepared and implemented national provisions of school education focusing on "globalization, modernization, decentralization, and localization of curriculum in the Nepalese context" (CDC, 2007, p. 1). But if we go through the mathematics curriculum of Nepal, we still can see that most of the part of the curriculum is covered with the ideas of western mathematics. The views of mathematics such as mathematics as a foreign subject, mathematics as a collection of symbols, mathematics as a meaningless subject, mathematics as a body of pure knowledge, and mathematics as an objective knowledge (Luitel, 2009) have demonstrated the worldview of most of the math teachers and curriculum experts in Nepal. Implementation of ethnomathematics in school level mathematics will contribute to addressing the current problem that has been arising in the context of school education in Nepal.

Culturally Relevant Pedagogy (CRP)

Works that advocated connection between home-community and school cultures in developing viable teaching and learning environment can be defined in a variety of ways: (a) *Cultural appropriate* (Au & Jordan, 1981); (b) *culturally congruent* (Mahatt & Erickson, 1981); (c) *mitigating cultural discontinuity* (Macias, 1987); (d) *culturally responsive* (Cazden & Legget, 1981; Erickson & Mahatt, 1982); and (e) *Culturally compatible* (Jordan, 1985; Vogt et al., 1987). In this research, I use the term *Culturally Relevant Pedagogy* coined by Gloria Landson-Billings in 1995, which places emphasis on the needs of students from various cultures. Landson-Billings (1995) specifically defined culturally relevant pedagogy as:

> A pedagogy of oppression not unlike critical pedagogy but specifically committed to collective not merely individual, empowerment. Culturally relevant pedagogy rests on three criteria or propositions: (a) students must experience academic success; (b) students must develop and /or maintain cultural competence; and (c) students must develop a critical consciousness through which they challenge the current status quo of the social order. (p. 160)

Thus, Culturally Relevant Pedagogy (CRP) is a way for relating school education with the household community and culture of the students through sensitivity to cultural nuances integrate these cultural experiences, values, and understanding into the teaching and learning environment. According to (Gay, 2000), when the discussion is about the connection between school mathematics and culture, one teaches to and through the strength of ethnically diverse students.

In the context of Nepal, a teacher has to carry different pedagogy to convince all the students in a classroom equally. The students in a Nepalese classroom are from different cultural groups with different cultural backgrounds. It is tough work for a teacher to teach mathematics effectively in such a type of classroom. A teacher needs to teach students from different ethnic groups. So, the teacher needs to conduct a frequent discussion with the students about their culture which will help the teacher to teach mathematics in the classroom (Ladson-Billings, 2001). It means that now there should be enough space for Culturally Relevant Pedagogy (CRP) in the mathematics classroom. Culturally relevant pedagogy "can be defined as using the cultural knowledge, prior experiences, frames of reference, and performance styles of ethnically diverse students to make learning encounters more relevant and effective for them" (Gay,2000,as quoted in Rosa & Orey, 2013, p. 29). CRP in mathematics

classroom helps a teacher to maintain a bridge between the cultural practices of students with the mathematics that they are going to carry out inside the classroom. CRP can assist a teacher in linking culture and social pedagogy. Implementing CRP in a classroom is not an easy task, a teacher need to prepare well, should collect the information of cultural practices of students from different cultural groups and must be careful about not being culturally biased. S/he should have a proper insight into his/her cultural background. “Culturally relevant teachers utilize students’ culture as a vehicle for learning” (Ladson Billings, 2001, p. 161). Through the proper integration of CRP, a teacher can develop numerous academic skills and competencies. “CRP maintains that teachers need to be nonjudgmental and inclusive of the cultural backgrounds of their students to be effective facilitators of learning in the classroom” (Jeffy S. B. & Copper J. E, 2011, p. 66). Students are highly encouraged to present their local knowledge, especially that they learnt from their daily life activities that they carry in their home. It helps students in constructing knowledge based on cultural diversity. Both teachers and students together can develop their required tools and materials to enrich their mathematical knowledge with local knowledge.

Moll and Gonzalez (2004) used the term funds of knowledge (FoK) to refer to “the knowledge-base that underlies the productive and exchange activities of households” (p. 700). They argued that the FoK approach helps to re-contextualize students activities with the mathematics that they read in a classroom. FoK approaches to teaching mathematics exhibit how family activities like gardening, cooking, sewing, playing games are related to the mathematics they read. Those activities can be mathematical resources available to students and teachers as well to support mathematics learning of children (Civil, 2007; Civil & Kahn, 2001; Turner et al., 2012). The researcher emphasizes connections to students' daily life activities with

learning mathematics in authentic ways. Bringing cultural mathematics in classroom can create a connection between mathematics and our culture, inter-relate cultural activities with mathematics that students perform in their daily life activities and cultural programs.

Ethnomodeling

Ethnomodeling is 'a process of elaboration of problems and questions growing form real situations that form an image or sense of an idealized version of the *mathema'* (Rosa & Orey, 2010, p. 18). This provides a critical analysis of generation of knowledge, institutionalization of knowledge and transmission of knowledge (D'Ambrosio, 2002, p. 142). Use of models in teaching and learning activity makes learning fun. I personally have experienced that while teaching mensuration, use of different geometrical shapes like pyramid, cylinder etc. make me easy in teaching and students also learn mathematics and I saw they enjoyed a lot in learning process and what they have learned, they are able to demonstrate their knowledge during problem solving.

Ethnomathematics may be defined as the intersection between cultural anthropology and institutional mathematics that utilizes mathematical modeling to interpret, analyze, explain and solve real world problems or mathematize existing phenomena (D'Ambrosio, 1993; Rosa, 2000; Orey & Rosa, 2003). Making models uses a big mathematical concept. Not in educational sector, but in all sectors, modeling is one of the best ways to show the concepts, processing of making, physical appearance of any project. In my class, now students make a model under given condition and explore the mathematics used in the construction of model and present their findings in the classroom. Ethnomathematics uses the different form of models of reality and modeling as a strategy to provide mathematical education uses

the organization of different mathematical shapes. (Rosa & Orey, 2010). With this context, D'Ambrosio (1993), Bassanezi (2002), Monteiro (2004), and Rosa and Orey (2006) stated that mathematical modeling is a methodology that is closer to an ethnomathematics program.

Cortes & Orey (2020) stated that current and ongoing work in ethnomodelling and ethnomathematics begins with looking at how diverse members of distinct cultural groups use mathematical thinking. What is common across all cultures is the basic human endowment that is the common way of thinking that allows all people to count, to order, to pattern, to measure, to model (Cortes & Orey, 2020). Teaching mathematics using ethnomathematics in classroom permits exchange of cultural practices among students. Students will get chance to exchange mathematical practices in their respective cultural practices.

Connecting Culture with Mathematics

Early knowledge acquired by youngsters is inter-related with culture and environment in which the children are born and grow up. Students come to school already having a considerable amount of prior knowledge and experience ingrained in them through their home and peer group cultural interactions (Sharma, 2017). If school mathematics could describe those student's experiences, then learning will fruitful, entertaining the students. According to Sharma, T., & Orey, D. C. (2017), When students attend school and encounter abstract subjects like mathematics, they find themselves disadvantaged because teachers as well as current mathematics curriculum do not encourage students to relate mathematics with their culture.

In accordance to Sharma (2012), if our children learn to see mathematics only form a foreign perspective, they might feel that our culture is less powerful and might not work with mathematics or, even worse, that they cannot work with the

mathematics that they see in schools, as it is for others. So, contextualization of mathematics in strictly necessary in mathematics curriculum. Although, present curriculum focuses on curriculum to contain a local subject in order to respect and preserve the local culture and tradition, still there we need prioritize contextualization of mathematics with our cultural artifacts so that students could find mathematics and its application in their daily life activities.

Theoretical Review

Theoretical literature review is one of the most significant section of my research. The theories are based on which ideas for the research can present. These theories will provide support to conduct my research more efficiently. Following are the theories, which guided me to conduct my research

Social Learning Theory

According to Vygotsky (1978), the development of the mind is originated from the interaction of the person with society. As all human beings are social animals, they all learn from society by interacting with different people. The processes of learning and cognitive development are not independent rather they go mutually. It means social interaction is one of the inseparable parts of learning. Students learn more through interaction and active participation in social interaction based on their prior knowledge. Therefore, cognitive development is a course of social interaction. However, the disadvantage of social interaction is that environment may cause unfavorable development of cognitive ability. Therefore, there should be an adult for the proper facilitation.

However, in the current education system, it is hardly found students getting involved in meaningful social interaction, as teachers feel comfortable in using the chalk-and-talk method while teaching mathematics. In the classroom, four/five

students sit together on each bench and the teacher stands at the front giving a lecture and sticking on the board solving routine problems of the textbook explaining the necessary algorithms, rules, formulae, etc. In this context, students just focus on copying the solutions written on the board and there is a doubt if students listen to their teacher sincerely. However, Nepali classrooms are full of children from diverse communities and cultures that can be used as a vast source of knowledge for meaningful learning of mathematics and hence the traditional classroom can be transformed into an effective learning place where students learn collaboratively in different groups and construct knowledge through social interaction and the teacher's proper facilitation. I also agree with Bature and Atweh (2019) who stated that collaboration is a learning process where learning focuses on cooperation between teachers and students and between students and students to solve a common mathematics problem.

Moreover, the traditional mathematics classroom can be done transformed into a meaningful learning place by integrating students' cultural practices. In this whole process, students get adequate chances to be familiar with each other's' cultural practices and learn different mathematical knowledge and practices embedded in their cultures where the teacher can play a facilitative role using ethnomathematical approaches to teaching and learning. Ethnomathematics is the application of mathematical ideas, procedures, and practices developed and applied by members of a specific cultural group in distinct contexts, which are often used currently in present day contexts (D'Ambrosio, 1985). In this regard, teachers should guide their students properly and encourage them to manipulate and relate the mathematical problems with the various mathematical knowledge and practices embedded in their cultural practices through reflective practices. Therefore, in my research study, social learning

theory guided me in connecting the mathematics curriculum with the cultural practices of students for making the learning process meaningful and more effective.

Habermas' Theory of Human Interests

Habermas' theory of human interest advocates that knowledge is not discovered but is generated or constructed (Habermas, 1972), This theory is taken as the most influential theory for the cognitive learning process and is also known as the 'theory of knowledge-constitutive interests' which determines the modes of constructing knowledge and whether knowledge claims can be warranted. I used Habermas' three knowledge constitutive interests as my theoretical referents for conducting my research. According to Habermas (1972) 'interest, in general, is the pleasure that we connect with the experience of an object in action' (p. 198). The three human interests by Habermas are Technical Interest, Practical Interest and Emancipatory Interest.

Technical Interest

Technical interest is a form of knowledge that is generated or constructed as objective knowledge through a series of experiments and observations in a managed, controlled or manipulated environment. This type of knowledge is arranged in a structure or arranged in a series of law-like hypotheses by which meaning is made under observation. This concept drives people to have a focus on the product of their knowledge and practices. Habermas believes that knowledge comes from things that can be experienced with the senses, action in the technical interest implies a need to control events rather than making meaning in the social world (Grundy, 1987b; Guba & Lincoln, 1989; Lincoln & Guba, 2000). In Nepal, the curriculum is developed as the curriculum as product. That means, once students read any topic on mathematics, they will be able to find the answer to get marks but at the same time if students are

unaware about the process of the problem. According to this interest, all the activities are focused on the product rather than process. This technical interest as a theoretical referent helped me dig out the traditional classroom teaching and learning practices that became a basis for me in exploring the possible ways of teaching and learning from the perspectives of cultural contextualization.

Practical Interest

Practical interest is the interest of the learner which generates knowledge through active social interaction among the people who participated in the interaction. The central idea is that the learner learns and generates knowledge by critically analyzing historical knowledge. Nevertheless, the learners participating in the social interaction should be rational so that they can put their logical arguments during the meaning-making process in constructing knowledge through consensual understanding. In my research study, this practical interest as a theoretical referent guided me to explore different mathematical knowledge and practices embedded in Newari Traditional oil mills through a prolonged interaction with my research participants. Further, it helped me explore the ways of contextualizing school mathematics through mathematical knowledge and practices embedded in the traditional Newari oil mills using ethnomathematical approaches to teaching and learning mathematics.

Emancipatory Interest

Emancipatory knowledge is a product of critical reflection and critical self-reflection (Cranton 2002). According to Habermas, emancipation means "independence from all that is outside the individual and is a state of autonomy and responsibility" (Grundy, 1987, p. 16). Emancipatory is possible only when there is an act of self-reflection (Shrestha, 2018). According to this theory, knowledge is based

on the critical analysis of the learning which is done through critical self-analysis, self-reflection, and self-awareness. With the integration of ethnomathematics in the mathematics classroom, students, as well as a facilitator, get a chance to reflect upon the use of mathematics in their own cultures. When students reflect on their own cultures, they will feel motivated to construct mathematical knowledge based on their prior knowledge perceived through different cultural and day-to-day activities. By doing such activities, they will be authorized to choose their own way in which they can represent mathematics in a different way other than others which makes them understand mathematics better. Moreover, I used this emancipatory interest as a theoretical referent to explore how students can be involved in critical self-reflection and empower themselves by raising questions about social and political injustices and disorders in mathematics education. Furthermore, this theory helped me critically explore different mathematical knowledge and practices embedded in traditional Newari oil mills from the research participants in the research field.

Empirical Review

Empirical review is important in research to know the position of a researcher in the research study. It provides the researcher with the different previous research studies, which had been conducted for the same purpose. In this regard, I reviewed the previous research studies relevant to my research study and located my position as a researcher.

Shrestha (2018) conducted his research study on "*Embodiment of geometry in traditional Newari art: An ethnographic inquiry*", in which he presented mathematical knowledge, especially geometrical knowledge while drawing Paubha in the Newari community. The main purpose of this study was to explore the mathematical application in Paubha drawing and incorporate the possible way to

integrate it with our curriculum. In this research, researchers had presented how people draw geometrical shapes while drawing Paubha and also shown the use of Golden ration in drawing Paubha.

Rai (2016) conducted his research on "*Mathematics Practices in Rai Community and Pedagogical Use*". The researcher conducted the research on the Rai community to present the cultural artifacts as mathematics learning material in classroom. For this, researcher spent time observing Rai community and their cultural practices and put forward the idea that how mathematical practices done in Rai community and pedagogical use.

Lama (2013) has conducted the research on *"Geometrical Knowledge in Socio-Cultural Activities of Tamang Community and its Place in Primary Level Curriculum Development"*. Researcher conducted the research in Tamang community and put forward the ideas which shows that mathematics is being practiced in Tamang community and the possible incorporation of those practices with the school curriculum to make the mathematics learning effective and interesting. This research also advocates for the incorporation of ethnomathematics in mathematics education.

Gurung (2014) had done a research on *"Mathematics in the Gurung Community: An Ethnomathematical Study"*. This research is conducted in the Gurung community of Ghandruk V.D.C of Kaski District and analyzed the different aspects of ethnomathematics with the help of mathematical practices in their community. In this research, he presented the possible ways to incorporate these practices in the mathematics curriculum of primary level specially on the topics number system, arithmetic operation, game and ways of making rectangle etc.

Gautam (2004) has conducted a research on *"The Concepts of Geometry in Tharu Culture: An Ethnomathematic Perspective of Tharu in Chitwan"* which focus

on the same theme. These are some research done by different researcher in different community. As I belong to a Newari community, these all research motivated me to do research on my own culture and uplift the Newari culture in the incorporation with mathematical education.

Research Gap

There are many researchers researching to find the ethnomathematical practices in different communities from different parts of Nepal. As Nepal is rich in language, culture, there are abundant spaces to find the ethnomathematical practices in different communities. From all the reviews above, I found that many researcher explored ethnomathematical ideas in their own culture. Some researcher had explored ethnomathematics in Newari culture. However, I could not find any research that had been conducted to explore the mathematical practices on my research topic using my methodology and theories that I have choose to conduct my research. Hence, I have decided to conduct a research and find the possible mathematical practices for the incorporation with the mathematics curriculum in mathematical education.

Chapter Summary

In this chapter, I have presented ethnomathematics and culturally relevant pedagogy as the main themes of my research. These themes helped me to execute my research and planning. I tried to bring different theories that provide thematic support to my research and I have tried to conduct my research in the basis of these theories. In theoretical review part, I have discussed social learning theory, Habermas Theory on Human Interest and conceptual & procedural knowledge. I found these theories support best for my research from all perspective. Similarly, in Empirical review section of my research, I had advocated that no research have conducted previously on the same topic. Many researchers had conducted research in different community

to find the mathematical practices in their culture. Many research studies had conducted in Newari community but no research had been conducted on my research topic even though it belongs to Newari community. Subsequently, these reviews provide enough support for the necessary guidance to find my research goal.

CHAPTER III

RESEARCH METHODOLOY

Chapter Overview

In this chapter, the methodologies I have chosen for my research is discussed. I have also included research design, selection of research site, sampling procedure, data generation, data collection tools and techniques of the research. The process of the data analysis are also presented here. It further offers the introduction about the research site and research participants. It also includes quality standard and ethical considerations of my research.

Research Paradigm: Interpretive

My research is guided by interpretive paradigm. According to Taylor and Medina (2011), interpretive paradigm is research process where researcher conduct research standing in the shoe of his participants, look through their eyes, feels their pleasure and pain. Thus, this paradigm is inter-subjective knowledge construction (Taylor & Medina, 2011). According to this paradigm the nature of inquiry is interpretive, and the purpose of inquiry is to understand the particular phenomenon not to generalize to a population (Farzanfar, 2005). For accumulating the mathematical concepts embedded in traditional Newari oil mill, I interviewed and deep prolonged engagement in the field for the fulfillment of my study objectives. For this, I had spent enormously of time in my research site.

Philosophical Perspectives of My Research

According to Tuli (2010), the selection of research methodology depends on the paradigm that guides the research activity, more specifically, beliefs about the

reality of humanity (ontology), the theory of knowledge that informs the research (epistemology), and how that knowledge may be gained (methodology). Axiology is also one of the paradigmatic considerations that deal with the values and norms.

Epistemology

Since my research is interpretive and, in this paradigm, researcher see the world as constructed, interpreted, and experienced by people in their interactions with each other and with their wider social systems (Maxwell, 2006; Bogdan & Biklen, 1992; Guba and Lincoln, 1985; Merriam, 1988). In my research, I tried to explore mathematical concepts, which is constructed, experienced by the people in traditional oil mill in construction, operation of oil mill and selling oil, which is a product of mill.

Ontology

In my study, I preserve a belief that there is no single reality since it may change per context and situations. During interview of research participants, I tried to make senses of their own lives and to appreciate their own construction of knowledge through their practice. I tried my best to enable and empower them to express freely their views to find and incorporate mathematical concepts embedded in oil mill.

Axiology

Axiology involves the values and belief systems of paradigm comprising study of values and goodness. I appreciate the views of participants. I always respect their views and all the words they had expressed during interview. I listen to them, agreed them but I capture only those ideas which are essentially worthwhile for my research agenda. In this research, the voices of research participants are reserved without any manipulation.

Research Design

I used ethnography as a qualitative research methodology for my research study. Since, the aim of my research was to exhibit the concepts of mathematical knowledge practiced in Traditional Newari Oil Mill, ethnography suits best my research design. I have visited oil mill many times, observed the working process of mill and have felt the feeling of the workers working in mill. After investing quality of time in observing various practices and procedures adopted in traditional oil mills, I have tried to explore the local ideas related different geometrical shapes used in construction of oil mill to mathematics teaching and learning. I tried my best to find the major strengths of bringing these processes in mathematical classroom and also tried to find out the possible merits and limitations of bringing those ideas 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 & Lincoln ,2011; Reeves et al., 2008, 1991). My primary task was to explore the mathematical concepts exhibited in traditional Newari oil mill; I have tried to find out how mathematical knowledge are practiced in behavior of Newari culture. I have tried to find out the possible ways to incorporate those ideas in teaching and learning mathematics approach.

Research Participants and Sites

Since my research is to study about the mathematical concepts of traditional Newari oil mill, I choose Khokana as my research site which is a traditional Newari community and people run traditional oil mill as their profession since long time ago. My research participants were the workers, owner in that mill and also some elderly

persons and local people of Khokana. Among them, one is mill owner, one is worker in the mill who have spent their entire generation running and working in the same mill. One is student who has published articles regarding oil and oil mill, and one is elderly person who has been witness for the many changes in the oil mill. I chose my participants via purposive sampling. I have spent adequate time talking with my participants regarding how they construct the mills, where they get the materials needed to construct and run the mill, how they make the shapes while constructing and running the mill. I also chose two mathematics teachers who have spent more than a decade of their life in teaching mathematics for primary and secondary level in Nepal. I have discussed the present condition of mathematics classroom and the possibilities of incorporation of the mathematical knowledge practice in different community, cultural groups of our society. Beside this, I frequently discussed with many other teachers, students, my thesis supervisor, and other faculty teachers to get some vital data for my research.

Tools and Techniques

Since my research is qualitative research and has ethnographic design, Observation and In-depth Interview as effective tool and technique for data collection to carry out my research more effectively. To explore the necessary data and information for my research, it was necessary to have prolonged discussion with my research participants and in-depth observation of their every action in the oil mill. Similarly, taking photos, videos of interview, audio recording and field notes provided additional help in receiving required information from participants.

In-depth Interview

One of the tool or technique to collect data and information in qualitative research design is an Interview. Interview is prolonged talk with research participants

and intended to provide detail information in any topic. For this, I have set questionnaires for research participants which provided plenty of space to present the views of the participants openly (Patton, 2002). I spent many hours talking to participants and the information provided by them provides encouragement to me to conduct my research more deeply. I am thankful to them that they never hesitate to demonstrate the working of oil mill.

The interview with the two currently teaching teachers was mainly focused in contextualization of culture in teaching and learning process. It mainly focused on the space provided by present mathematics curriculum in incorporation of traditional mathematical knowledge in teaching approach. I tried to get necessary information and the possible ways to contextualize and incorporate the traditional mathematics in present curriculum.

Observation

To understand how they run the oil mill and how they constructed it, I needed to spend sufficient time in observing their daily life activities and traditional works of making shapes of different parts of mill. During the whole process of observation, even I had an opportunity to compare the different approaches of acquiring mathematical knowledge form the traditional artifacts. "Unquestionably, observations represent a frequently used form of data collection, with the researcher able to assume different roles in the process" (Creswell, 2012, p. 212). In-depth observation was carried out multiple times regarding the geometrical practices in traditional oil mill. Different types of geometrical shapes were observed along with their function in operation of oil mill.

Field Notes

Field notes have been other important tools for the collection of data in my research. During my research, I frequently visited to research site, talked with participants and took the field notes. I tried to have short talk with my participants to collect the necessary data from my participants. As they were working, so during my research, I talked with them in such a way that they did not feel disturbed. They talked with me by doing their work. By taking field note, I could note overall physical setting of my research site (Bogdan & Biklen, 1998). Field note helped me to review my research whether I am able to address the answer for my research question in a proper way or not.

Data Analysis and Interpretation

The data and information collected through different data collecting tools and technique must be arranged properly. After analyzing the data properly then it was interpreted wisely to make meaningful sense for my research. It is one of the toughest parts of research to draw the conclusion and relate the result with the research question. For this, I transcribed the audio, videos that I have recorded during interview with research participants. After systematic investigation and arranging field notes, audio, videos that I have collected, data analysis was done which amplify my understanding and to facilitate myself to present my findings in more effective ways (Bogdan & Biklen, 1992).

According to Creswell (2012), there are three steps of data analysis and interpretation which are described as follows: The first step is to organize and prepare the collected data for analysis. For this collected data should be managed, transcription of interviews and typing field notes. Once, first step is done, second step is to explore and code the data. For this, a researcher should dive into the data and

gain a sense of data for the research. The third step is to represent and report qualitative findings.

Quality Standards

Quality standard ensures the Reliability and Validity of research. According to Babbie (2004) 'reliability' is a matter of whether a particular technique applied repeatedly to the same object produces the same result each time and 'validity' refers to the extent to which an empirical measure adequately reflects as the real meaning of the concept under consideration. My research aims to preserve the following quality standards:

Credibility

Credibility means did the researcher undertake prolonged immersion in field, check his/her interpretations with his/her informants, and display a process of learning? (Taylor & Medina, 2011). That means how much a researcher spent time in research site for interview and collection of data. For this, I spent four weeks talking to my research participants, collecting data and photos. Here I have strongly maintained the credibility in this research.

Dependability

Dependability means did the researcher engage in open-ended or emergent inquiry? (Taylor & Medina, 2011). During data collection process, I had spent enormous time talking to my participants. They always supported me to explore any kind of knowledge from oil mill. Even COVID pandemic situation, they always agreed to talk to me, answer my all queries, received my every call and provided me every detail information needed for me. To maintain credibility, I tried best to ensure that whether my findings were well arranged, presented in meaningful way or not. By doing this, I could grow my confidence on my research finding. The research

participants were given equal chance to express their feeling, beliefs, opinion about the research topic. They can quit interview at any time if they feel my research is not respecting their social values and their feelings. Semi-structured questionnaires were designed to ensure the dependability of the research.

Transferability

Transferability means is there sufficient rich description for the reader to compare his/her own social context with the social setting of the research? (Taylor & Medina, 2011). To maintain transferability in my research, I will try to bring my research finding in practical life for good. I will try to demonstrate the way my research equally respect and applicable to other groups on exploring mathematical practices in their day-to-day life.

Trustworthiness

Every researcher must think about trustworthiness as it is an important quality standard. “Research findings should be as trustworthy as possible and every research study must be evaluated in relation to the procedures used to generate the findings” (Graneheim & Lundman, 2003, p. 109). I have tried my best to maintain trustworthiness of my research by going to the real field, taking interviews of my research participants, appreciating, and understanding social state, perspectives of participants by talking in personal with them. I have also maintain credibility through prolonged engagement by frequently visiting the site, interview, sharing, discussing my research topic repeatedly.

Pedagogical Thoughtfulness

Pedagogical thoughtfulness is the quality of research writing that engages the reader and writer in thinking about educational issues, especially teaching and learning (Ellis & Bochner, 2000; Howitt, 2008). In my research, I tried to explore the

mathematical concepts used in newari traditional oil mill along with the possible ways to incorporate my findings in mathematics teaching and learning process. The findings of my research possess high significance in classroom pedagogy and can contribute well in successful mathematics learning (Manen, 2008). Being a researcher and a teacher, I will try to reflect my research findings on my own pedagogical practices.

Ethical Considerations

According to Orb et al. (2000), "Potential ethical conflicts exist in regard to how a researcher gains access to a community group and in the effects the researcher may have on participants" (p. 93). In my research, I was trying to explore the mathematical concepts in traditional Newari oil mill in Khokana. Being a part of Newari community, it was easy for me to convince my research participants for my research. For this, first I made my participants clear about the purpose of my research to get sufficient data. I convinced them that my research will be only for academic use and I will destroy all the collected data and information after I finish my research. I emphasized on setting up a good relationship with the research participants and also a comfortable environment in which the research is going to carry out. Then I chose my participants for prolonged discussion. I never forced them to be my participants. I did not pressurize them physically and mentally to take part in my research and they can quit at any time. They fully supported me to carry my research even in lockdown time and finally I could collect all the necessary data, photos requited for my data.

Chapter summary

In this chapter, I have discussed in brief about the major methods that guided me to conduct my research in organized way. I presented my views how I chose my research topic, research site, participants who had supported me by providing valuable

data and information that helped in answering my research question. I briefly described the tools and technology used for data collection and the data analysis and interpretation process. Beside this all, I also tried my best to make sure that my research includes all the demanding quality standards. During data analysis and interpretation, special care was given in drawing the meaningful cultural aspects of mathematics from the collected data. Additionally, various ethical considerations needed to conduct my research were also presented in this chapter.

CHAPTER IV

MATHEMATICAL KNOWLEDGE PRACTICED IN TRADITIONAL OIL MILL

Chapter Overview

In this chapter, I explored mathematical practices that are embedded in traditional oil mill. After interviewing research participants, I came up with valuable insights which I discussed in this chapter. I tried my best to present all those traditional approaches that Newari community adopted while constructing and operating traditional oil mill. For this, I observed traditional ways of drawing geometrical shapes using big wooden logs in giving proper shape for mill. People have invested generations working in oil mill as their family occupation. According to owner of the mill, the tools having different geometrical shapes used in oil mill were presented by Prime Minister Junga Bahadur Rana and these tools are still in good working condition. People are still using the same materials and same method and techniques to operate the mill.

Historical Background of Oil Mill in Nepal

Mustard oil expelling is one of the most traditional technologies practiced in Nepal. In my research, historical place Khokana is my research site which got a long history. Since a long time back, people in Kathmandu valley had been using mustard oil for cooking purpose and most of the mustard oil in valley was supplied from Khokana. During those days, there were many oil mills in Khokana but now due to different technologies, only one traditional oil mill is under operation for expelling oil. Kathmandu valley has basically three stages of development of traditional oil mill (Maharjan, 2005). They can be categorized as

i) Before 1944 AD ii) 1944 AD to 1968 AD

iii) After 1969 AD

Before 1944 AD, the occupation of mill was extremely difficult due to lack of access of the knowledge of machinery devices. Mustard oil expelling mills made of wood used to huge in size and these mills were totally depended on human force. At that time, only multi co-operative/Guthi run mill.

In around 1944 AD, the ideas of screw mills were introduced. Screw mills were successful to reduce the size of traditional oil mills to a much extent. But the similarity between the two is that both of them used huge wooden planks to expel mustard oil. Use of screw increased the efficiency of oil mills.

With the new inventions in modern technology, weaknesses were automatically seen in the screw mills. People felt that they could neither expel oil form hard seeds like soybeans nor could expel oil completely form the mustard seeds. These weaknesses let to the introduction of modern expellers which replaced the traditional technology as result modern expellers were introduced to Kathmandu valley in 1968 AD.

According to Mr. Kancha, *"I have spent my entire life working here in traditional mill. I don't know the actual time when this mill was constructed but my grandfather said that his forefather built this mill and he don't have any idea that how they build this at that time. In different natural calamities, the mill had destroyed and re-constructed. The wooden logs used in present mill were gifted by Prime Minister Junga Bahadur Rana. They bring wooden materials from the forest of Thankot. There used to be many such oil mills. Few of them were destroyed in different natural calamities like earthquake; few of them are not in run because of difficulties to operate them. Now the only running oil mill in Khokana which is run by a co-*

operative is expelling oil through traditional way. Many people from Nepal and other countries come there to observe that mill."

According to Mr. Ashalal, "*I used to sell mustard oil in different part of Kathmandu valley. I use Mana, Pathee as measurement unit to sell oil to people. But the government officers don't allow using mana, pathee as measuring tool. Instead of that they suggest using liter. Many times officers snatch the measuring device if they saw using it. So, I hide this mana, Pathee measuring tools and shows liter measurement tools because people at that time don't buy oil in liters".* After talking to him, I realized that Eurocentric mathematics had dominated local mathematics even those times. Government suggests using liter measurement instead of local measurement tools like *mana, Pathee.* By studying about this all, I have tried to present the cultural aspects of mathematics which is generally regarded as pure and neutral subject (Bishop, 1993; D'Ambrosio, 1990).

Process of Oil Expelling

Fig. 1. Modern machine for pulverization of seeds

According to Mr. Kancha, *"we collect the mustard seeds from different parts of Nepal as well as from China. First all the collected seeds were stored in a place and then dried in sun for few days. Local women filter all the unnecessary parts like small piece of stones, soil from mustard seed. Dried mustard seeds are first pulverized in a grinder called Dhiki or Kuti in the local term. But nowadays, Dhiki or kuti are not in use as it needs more human power for pulverization. To increase the work speed, now we use modern machine for pulverization. Using this machine, work efficiency is higher than using traditional tools like 'dhiki' or 'kuti'. Pulverized seeds are roasted in the mud stove. 0.75 to 0.5 liters of water is sprinkled during roasting in the 18 Kg*

of pulverized seeds. The quality is called 'Chapaya' in local term. Then roasted seed is put into the cane bag called 'Pau' and pressed in between the wooden logs called 'Gansins' which is attached with metal screw. The one end of metal screw is a wooden cross which is called ''ghachaa''. The ''ghachaa'' is rotated to press on the 'gansins', and 'pau' containing roasted pulverized seeds is pressed and pressed it until oil starts coming drop by drop. In this whole process, only 80% of oil extracted from the seed because pressing in 'gansins' only cannot extract 100% of milk. Hence, oil cake is hammered and turn into small pieces. Then these pieces of oil cakes are kept in modern oil extracting machine where remaining amount of oil is extracted. Once oil is completely extracted from seed in modern extracting machine, the residue (Khau in local word) is collected properly in a place because these residues also have specific traditional uses. In Newari culture, it is spiritually used as human body purifier. I mean, in our culture, if we wet our hair from this, our body gets purified for spiritual purposes like shraada. Also, it is used as compost manure. We sell it at Rs. 80 per kg." For my question, what is the exchange rate of mustard seeds and extracted oil? He answered, *"The rate of exchange is 1 Mana oil = 5 to 8 mana of mustard seeds depending upon the quality of seeds."* All the materials used in mill have some geometrical shapes and mathematical ideas. There are many possibilities to make the mathematics learning more interesting

Fig. 2 . Modern oil extracting machine

Fig. 3. Collection of oil pressed

and efficient if that mathematical knowledge is well explored. Various methods of drawing geometrical figures and learning mathematics can be presented in classroom as an ethno-modeling (Rosa & Orey, 2010).

Materials in Oil Mill

As I have named different parts of oil mill, which are mostly made from the wood. Different parts are assembled as shown in fig: 4. and represents the only one running traditional oil mill in Khokana named as *Gabu Jyasaa Oil Mill*. This mill is expelling oil form mustard seeds.

Fig. 4. Traditional oil mill

According to Mr. Kancha, it was established more than 500 years ago. In its life, it has faced different natural calamities, some time it was not in use because of technical and social problems. After re-construction, it is in present condition and expelling oil and supplying in different parts of the country.

My research aims to explore the mathematical concepts used in this mill. These kinds of mills were constructed in Nepal when people actually don't know about mathematics. Ascher (2002) views how indigenous people observe their own ways of looking and relating the world with each other. Newar people also have their own way of generating knowledge. All the shapes and material were made up of wood when there were no modern technologies to give these shapes. In this research, I aimed to explore the mathematical ideas in this mill.

Mud Stove

Mud stove is a place where pulverized mustard seeds are roasted and make it ready for pressing in *gansins* to collect oil. This is of the traditional way of roasting seeds. Its shape is cuboid. The upper part is covered by hemispherical shape where pulverized seeds are kept for roasting. The diameter of this hemispherical shaped object is 2 to 3 *haat.* There is also a small hole to put firewood during heating. Seeds in hemispherical shape are stirred continuously so that seeds are roasted properly.

Fig. 5(i). Mud Stove

Fig. 5(ii). Mud Stove

Bishop (1991) viewed that education cannot be truly effective unless it is based on culture of students. In this mud stove, different mathematical shapes like cube, cuboid, hemisphere, hollow hemisphere can be observed. While doing measuring and calculating area and volumes, students can practice here finding dimensions of mud stove, area, volume of hemispherical object on the top. With this, we can introduce different shapes and the process of calculations to the students. Hence, it is said that "there is no sense in regarding mathematics learning as abstract and culture free" (Bishop et al., 1993, p.1). In beginning students might feel complex but once they understand the cultural mathematics that they use in their culture, learning will be fruitful and entertaining. In this whole process, students can construct their understanding through proper observations of such cultural artifacts (Rosa & Orey, 2008).

Pau

'Pau' is a typically Newari word given as name of the object which contains roasted seeds put in between two huge logs of wood, called *'gansins'* which is attached to metal screw. In ancient time, it is made up with the metal strips but nowadays for convenient; it is made up of plastic strips. Geometrically, it is pentagonal shape i.e., it has five sides. One end of *'pau'* is wide open, and another end is closed tip. One end is open to put roasted mustard seeds in *'pau'* and another end is closed tip to collect the oil at one point. This is the genuine mathematical reason for making the shape of *'pau'* pentagonal. While teaching in classroom, students feels that where the shapes have used in our daily life? Students were unaware about the use of mathematics in our daily life. We have been using mathematics in our culture. If we bring this object in classroom, students can investigate mathematics used to make the object as well as the learning will be meaningful and interesting. Bringing this in mathematic classroom can lead to culturally responsive teaching pedagogy since "using the cultural characteristics, experiences, and perspectives of ethnically diverse students as conduits for teaching them more effectively" (Gay, 2002, p. 106).

Fig. 6. Pau

A honeybee that does not have any mathematical idea always makes regular hexagonal shape for storing its honey. This is one of the ways of natural mathematics. All living beings have their own way of using mathematics in their daily life. Students would be fonder to use these objects 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 is can be easily discussed in the classroom with the help of manipulative" (p. 53). This object can use in classroom relating the plane shapes of combine solids like cone and cylinder. Though, there are other geometrical shapes available in the market, bringing these shapes will make feel students that mathematics is not an abstract subject, mathematics is being used in their daily life at home, at playground in their day-to-day life. So, mathematics is an inseparable component of living animals and plants, and it is relevant to every practice of human beings. All mathematics across the glove emphasize the contextualization of mathematics believing that mathematics is not absolute truth and universal knowledge which can be learnt through continuous practice and rote memorization, but it is corrigible and fallible in nature and relate directly to human life (Ernest, 1991).

Fig. 7. The pattern made by honeybee
*Source: https://miro.medium.com/max/6484/1*xClTy4IZ5S7BMKX1MD6reA.jpeg*

Gansins

'Gansins' is a huge wooden log which is use to press the roasted seeds kept in *'pau'*. According to Mr. Kancha, its shape is made huge so that it could create huge pressure in *'pau'* and could press it with bigger energy to expel complete oil from roasted seeds. There are two *'gansins'*. Out of them, one is fixed in its position and one can move its position horizontally with the help of

Fig. 8. Gansins

screw attached to it. With the help of screw, large amount of pressure is created in *'gansins'* to press seeds.

When we look into *'gansins'* through mathematical lens, it is cuboid in shape. It is made cuboid in shape to make the surfaces plan due to which equal pressure can be applied in all parts of *'pau'* to extract oil. We can take this as one of the great examples of cuboid and use it in pedagogical approaches. The major advantage of using this pedagogy is that students will get an opportunity to get out of classroom bounded with four walls and can learn geometrical shapes in artistic way in a class with no walls. They can be made familiar with these shapes with the fact that mathematics is not just bounded in books; it has been used in our day-to-day life long time back beyond formal academic setting (Bandeira & Lucena, 2004). This can be effective for those students who stay aside while learning mathematics (especially geometrical shapes and its area and volume) to drag them into the imagination and beauty of mathematics in different way (Orey, 2000).

Once the pressing is completed, *'pau'* is taken out of the *'gansins'* and roasted mustard seeds inside the *'pau'* are now converted into oil cake which is exactly the shape of *'pau'*. In teaching and learning process, it can be related with the problems where one shape is changed into another shape and students need to find some missing dimensions. "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 students" (Rosa & Orey, 2006, p. 34).

Fig. 9 . Oil cake

Ghachaa

Fig. 10. Ghachaa

'Ghachaa' is a wooden cross which is connected with *gansins* through metal screw. *'ghachaa'* is rotated to press *'gansins'* and *'pau'* containing roasted mustard seeds. It is rotated back to un-press *'gansins'* after complete extraction of oil from roasted mustard seeds. According to Mr. Arjun (worker in mill), before people use metal screw, huge human force was needed to operate the mill. *'gansins'* were pressed by people, and it takes more time and manpower. Once metal was discovered, then *'ghachaa'* was also given to cross shape as shown in fig. 10 to make easy to press *'pau'* by *'gansins'*. There is a special reason in making its shape cross. A person can climb up and can use his/her weight to tighten *'gansins'*. In educational word, it helps to multiply the force applied in *'gansins'*.

When we look into *'ghachaa'* through mathematical lens, its shape represents '+' (Addition) and '×' (Multiplication). If we go through physics, it can be good example of screw in simple machine as well as we can teach them about circular motion. Doing so, students will be aware about the uses of simple machine in their culture as well as they will be able to relate other examples which they are using in their day-to-day life. Doing these activities, students will be able to see the status of school pedagogies that we have currently in mathematics classroom (Borba, 1993). 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. This pedagogy can make classroom more fun and

interactive. Gardner (1993) has discussed about the various intelligence of learners. Everyone is culturally intelligent, and every culture is rich in mathematical concepts. We learn better if learning is connected to our daily life. When students find relation of mathematics with their culture, they will fill ownership in their learning process. They can learn mathematics in such a way that they are learning their own culture.

Measurement System

Measurement means comparison of unknown quantity with a known quantity. In ancient time also, people use different types of local tools for measurement. Since people in Khokana produces oil for trade, they need some way of measurement. For that they still use traditional way of measuring oil like *mana, pathee* etc. Ascher (2002) views how indigenous people she observed have had their own way of looking at and relating to the world, the universe and to each other. The Newari people also have their own way of generating knowledge. Mr. Kancha said, *"Even we have standard measurement system for measuring liquid like liters, people prefer traditional measurement for measuring oil in the mill. People already have a habit of*

Fig. 11(i). 1 mana

Fig. 11(ii). 2 mana

Fig. 11(iii). 8 mana=1 Pathi

this measurement, so they prefer this measurement. We use liter for measuring oil only for packing of oil for market sell. Because of modernization, most of the people now know the liter measurement system for liquid. They don't know about the mana pathee measurement system. That's why we need to pack oil measuring in liters

instead of mana, pathee". For my question, "how this *mana, pathee* are made? Is there any standard amount of substance in 1 *mana* or you make a random shape?" Mr. Kancha replied, *"my forefathers made a cylindrical shape for mana, pathee for measurement. And it is said that mana is the volume of measuring vessel that contains ten handfuls. Pathee is the volume measuring vesses that contains eight mana. Muri is volume that contains 20 pathee".* Pradhan (2017) has also mention these units of measuring volume. In his research, he mentioned the following units of volume.

Mana is the volume measuring vessel that contains ten handfuls.

Pathee is the volume measuring vessel that contains eight mana.

Chauthai is the smaller units to measure the volume and it contains quarter of mana.

Chakhanti is the smaller unit to measure the volume and it contains quarter of chauthai.

Chimti the substance held between three fingers thumb, index and middle.

People use *mana, pathee* as measurement tool not only for measuring oil; they use it for other measurement purpose also. They measure almost all kind of productions they grow in their field on the basis of *mana, pathee* system. There is special relation between *mana, pathee* while measuring. Vygotsky (1978) argues that the construction of knowledge is not a matter of individual, solitary construction of understanding, but a dialectical process firmly grounded in a system of social relations.

Ethnomodeling Process

"Ethnomodeling privileges the organization and presentation of mathematical ideas and procedures developed by the members of distinct cultural groups in order to facilitate its communication and transmission across generation. These construct

ethnomodels of mathematical practices found in sociocultural system" (Rosa & Orey, 2010b, pp. 68-69). Throughout history, researchers and investigators have made extensive use of mathematical modeling procedures ranging from statistical methods for elucidation of patterns in behavior to the mathematical presentation of logic processes of indigenous and local conceptual systems (Rosa & Orey, 2010). People are using mathematical knowledge in their own cultural group from a long time ago. So, in this section I will try to explore the mathematical ideas in oil mill through ethnomodeling.

Ghachha is one of the most important parts of oil mill. Its shape is shown in fig. 10 and I have described its function in oil mill. People are using it since hundreds of years ago and are not aware about the mathematics in it. I have put my views and finding during my research in the following way.

When *'ghachaa'* is rotated, it forms a circular shape. So it clearly gives the definition of circle i.e. *Circle is a path traced out by a moving point with respect to a fixed point keeping distance between moving point and fixed point always same.* Here moving point is any one end point of the handle and center is intersecting point of handles. The total length of handle represents the "diameter" of a circle and half-length represents "radius" of a circle. Using *'ghachaa'*, we can show how circle is used in our day-to-day life. We can give other examples as well. There are other easy and complete circle shaped traditional objects which can be used to elaborate

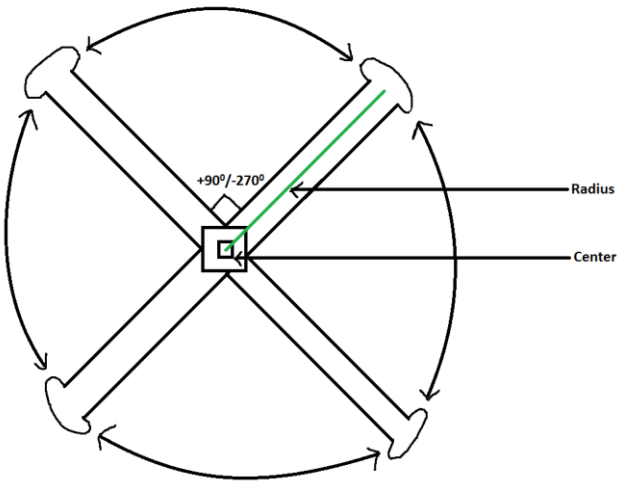

Fig. 12. Model of Ghachha

circle in teaching and learning activities. Through this *'ghachaa'*, we can easily demonstrate the practical use of rotation through different angles. Here in *fig. 12,* center can be taken as center of rotation and we can take one end point of handle as object. When handle is rotated, object also rotates making different angles. We can easily show clockwise and anti-clockwise rotation. And the most important is that most of the students don't have actual understanding that clockwise 90^0 rotations and anti-clockwise 270^0 rotation are same. So through *'ghachaa'*, we can easily demonstrate how these two rotations are same and have same image even the angle of rotation is different. In the same way we can easily demonstrate the rotation of other angles as well. Use of those cultural characteristics, experiences, and perspective of ethnically diverse students as conduits for teaching them more effectively (Gay, 2002). 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 manipulative" (p. 53). This tool can be used to make students make understand about the perpendicular lines, circle, rotation, and the properties of rotation.

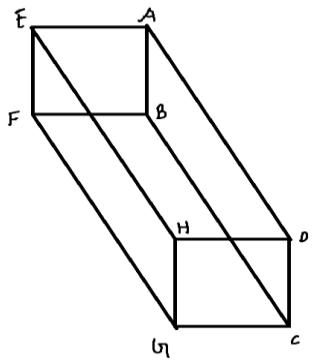

Fig. 13. Model of Gansins

Another most important part of oil mill is *gansins.* As it is huge wooden log shaped in cuboid shape, we can take this cultural mathematics inside classroom for teaching Total surface area of cuboid, volume of cuboid, and for combine solids of cuboid shape. As shown in *fig. 13, gansins* is exactly cuboid in shape. During teaching and learning activity, we can take students in to visit the traditional places where these shapes are in used for cultural work process. Doing this, students will get chance to come out of teacher centered learning approach from classroom and will see

the connection of mathematics with their daily life and how their forefathers used mathematical ideas for constructing cultural things like oil mill. Students will feel ownership in learning mathematics as they see tremendous mathematical ideas, they use in their day-to-day life and in culture. In *fig. 13*, its clearly seen that there are altogether six surfaces ABCD, EFGH, AEGD, FBCG, AEFB and CDHG. Here, opposite faces are identical. That's why, their areas are equal. In the same way, all the surfaces opposite to each other are equal to each other. So, the total surface area of given cuboid object is equal to the sum of area of six surfaces it have. Simply, here we will use the formula for *Area (A)= Length ×breadth* for finding the area of rectangle. But in case of combined solid, it would be very helpful to make concept clear to the students even though students are low performer in mathematics.

Fig. 14 is model of two *gansins*. A traditional oil mill also consists of two *gansins*. When two *gansins* were pressed, then oil is extracted from mustard seeds. As shown in figure, there are two *gansins* of cuboid shaped. And as we already discussed, each cuboid consists of six surfaces. When these two cuboids were combined together, two rectangular surfaces ABCD and A′B′C′D′ overlapped with each other and then we cannot see these surfaces. While calculating TSA, we will find the area of only those surfaces which are visible to us. Thus, in this case, TSA of combined solid is

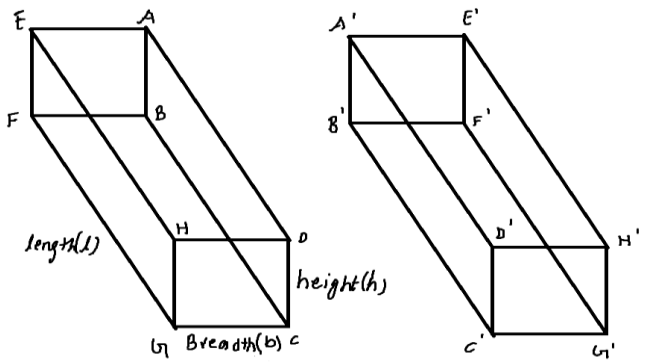

Fig. 14. Model of two Gansins

TSA= Area of rectangles (ABFE + CDHG + BCGF + ADHE + EFGH + A'D'H'E' + A'B'F'E' + C'D'H'G' + B'C'G'F' + E'F'G'H')

We have added five surfaces from each cuboid and we did not add that surfaces which overlaps with each other. By describing this, we can derive the formula for finding TSA of two combined cuboids.

$$TSA = 2(lh+lb+bh) + 2(lh+lb+bh) - 2(lh)$$

$$\therefore TSA = 4(lh+lb+bh) - 2(lh)$$

On the basis of students' observation on oil mill and derivation of formula for finding TAS of combined *gansins,* it would be easier for students in finding TSA and volume of other types of combined solids. Because of this reason, there is need to incorporation of such cultural approaches in school curriculum. Ethnomathematics can bring students cultural background in front of the entire classroom in more effective way (Rosa, 2010). This cultural aspect of mathematics is carried out of classroom and comparatively student-centered approach. So, students can generate knowledge and mathematical ideas in different way and can understand and remember for the long time.

During the process of extraction of oil, there I found a relation between the volumes of two different substances. That is; we can extract 1 *mana* of oil from 8 *mana* of healthy mustard seeds. Here, the exchange rate is 1 *mana* volume of oil (liquid) is equivalent to 8 *mana* volume of mustard seeds (solid). On observing this whole process, students can understand the relation between the volumes of two different substances and the actual meaning of the relation. Once students observe this relation by themselves in the mill, then it will be easy for a

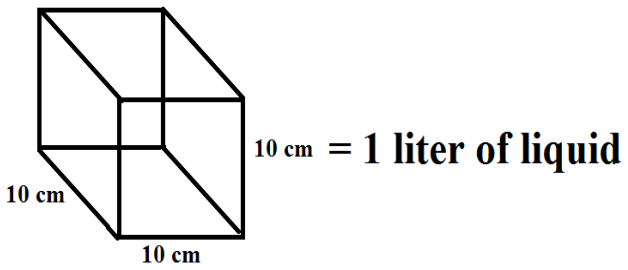

Fig. 15. Relation between liter and cm^3

teacher to teach them the relation between two different units of volume cubic centimeter and liters. I personally experienced that most of the students get confused always in converting liters into cubic centimeter and vice-versa. Therefore, students will feel easy in this conversion once they observe oil mill. During the observation, students can see the whole process of extraction of oil and there they can see how 8 *manas* of mustard seed produces 1 *mana* of oil. In the ethnological study, students identified characteristics of this particular group so that they were able to understand some of the cultural elements that shape their mathematical thinking (Bassanezi, 2002). In our present curriculum, students need to learn the relation between 1000 cm^3 is equal to 1 liter. Students can learn this relation by comparing the extraction of oil from seeds. As show in *fig. 15*, a cube of length 1cm can hold 1 liter of liquid in it. If volume of liquid is increased, then it overflows from the cube and at the end only exactly 1 liter of liquid remains in cube. In the same way, students will understand the relation between $1m^3 = 1000l.$ The construction of these kind of cube and volume of liquid in it is an excellent example that typifies the connection between ethnomathematics and mathematical modeling (D'Ambrosio, 2001). Once students understand this relation, they will be able to solve the problems related to this conversion like find the capacity of tank when internal dimensions are given, find the volume of metal required to construct the tank, conversion of one shape of object into another shape and finding the missing dimensions. In this way, mathematical modeling can be considered as a pedagogical tool in teaching and learning activities (Read, 2002).

Traditional Oil Mill as a Tool/Process for Culturally Relevant Pedagogy

Teaching mathematics efficiently in any classroom is one of the most challenging parts of teacher. Being a teacher, even I felt teaching mathematics as a

challenging job for me because in every class I teach, there are students from different cultural groups. We teachers are highly likely to face students whose culture, ethnicity, language, race and social backgrounds differ from one another (Howard, 2003). But as a teacher, it is my duty to teach all students from diverse community in teaching and learning process. The learners may feel difficulty in learning process since their culture different from one another. Teaching pedagogy in the classroom may favor only the dominant culture. If so, it might create problem in learning process. Hence there is the need of reform in classroom pedagogy. An introduction of traditional oil mill can empower the students from their culture. Traditional oil mill is not just run by any one ethical group. Almost all part of Nepal, people use traditional oil mill for extraction of oil from seeds. An idea of CRP helps teacher to setup classroom environment in such a way that students can work together for finding common conclusion. CRP pays more attention in respecting diverse culture of the students in the classroom and tries to enhance the students' achievement and can contribute a lot. (Ladson-Billings, 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 expericiences and community situations" (Hackett, 2003, p. 329).

While talking to a mathematics teacher, who had taught mathematics for decade of time, he shared, *"Incorporation of different culture in mathematics classroom is one of the best ways to teach mathematics. Doing so, students will get chance to see the uses of mathematics in our daily life. Not only daily life, but students will also get chance to know how mathematics is used in their culture. It is beneficial for both teachers and students. Students can develop mathematical understanding*

with the help of tools used in their tradition whereas teachers get chance to conduct further research in search of more classroom activities. And the good news is school curriculum also has granted this provision to teach local cultural subject and we as a teacher have good opportunity to make students realize about their and our cultural mathematics. And one more important thing, some of our culture is about to extinct and present generation is completely unaware about their culture. So, while choosing cultural mathematics, we teachers need to take special care. Selection of wrong cultural mathematics that students don't follow now may make more complications in teaching mathematics." So, 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 that teacher choose the proper cultural mathematics in multi-cultural classroom setting and create ideal environment with good relationship between school, teachers, students and parents. With the cultural equity in the classroom, we can enhance students' academic competence, professional confidence and development. Gardner (1993) has discussed about the various intelligence of learners. Every student are culturally intelligent and any intelligence can be improved.

Hence, introduction of traditional oil mill and other various cultural knowledge ease out teaching and learning mathematical knowledge. Relating local mathematical knowledge and academic mathematics can make learning mathematics easy, interesting and fruitful.

Chapter Summary

In this chapter, I explored the mathematical aspects of traditional oil mill in Khokana. I have discussed geometrical shapes that are used in mill and linked with the mathematical shapes that we teach in school curriculum. Also I tried to connect some physic which is used in the operation of mill. And lastly I tried to explain the transformation with the help of *'ghachaa'*, TSA of cuboid with the help of *'Gansins'*, TSA of combine cuboid with the help of two *gansins*, relation between the volume of cube and liquid contained in it with the help of conversion of mustard seed into oil. I tried to discuss the possible answers for my research question. For this, I spent considerable time with my research participants.

CHAPTER V

FINDINGS, CONCLUSION AND RECOMMENDATION

Chapter Overview

This section deals with the findings of my research in terms of the data collected from the field. The analysis of the data was completely based on participants' words, direct quotations and the images of the different parts of oil mill. During my research period, I have encountered with abundant ethno-mathematical knowledge embedded in traditional oil mill. I tried to show some of my suggestions, recommendations on practicing ethno-mathematics in classroom during teaching and learning activity.

Reprising My Research Journey

Since I belong to a Newari community, I had celebrated many cultural ceremonies. Not only just ceremonies, Newari culture is rich in arts and architectures also. People get knowledge about those arts and architectures even they had never attended any kind of formal education. As I belong to Newari community, these arts and architectures are inseparable part of my life. I always wonder how people can built/make these artifacts in such a beautiful and fine form. I always seek to learn how people make these all without having any formal education. I used to learn making shoes from straw with my grandparents; I used to observe how my mother make *sukul* from straw.

I join KU for my masters. Here in KU, I was taught about ethnomathematics. I came to know that my culture is rich in terms of mathematics also. Then I always tried to explore the mathematical ideas in my culture and cultural artifacts. My vision

to see my culture has changed. Now it is not just a culture for me. I always tried to find the possible ways to incorporate this cultural knowledge in classroom. I got change to learn more about my culture and cultural mathematics as I engage in more activities in KU. So, I choose to explore the mathematical concepts in Newari traditional oil mill. When I started research about oil mill, I came to know that this kind of oil mill is used not only in Newari community; it is used in other communities as well. So later I realize that not only Newari culture is rich in terms of mathematical ideas, in Nepal there are so many other cultures which are rich in mathematical knowledge. Every cultural group is able to develop their own geometrical concepts and have also done in numerous ways (Shrestha, 2018). 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).

I invested noticeable amount of time discussing about the mathematical knowledge used in traditional oil mill with my participants whose generation had been working in mill. I am glad that my research participants assisted me in every step of my research. They are ready to talk to me even COVID pandemic is hitting all over the world. They always welcomed me even in lockdown time. I interviewed them, took photos and videos, made phone calls and collected sufficient field notes as data for my research. I have gone through numerous papers on ethno-mathematics during my research period. Those papers helped me a lot in collecting necessary information and for my research.

Exploring mathematics in traditional oil mill was one part of my research and as per my second research question, “How can those mathematical concepts be contextualized in school mathematics teaching and learning approach?” I tried to answer both of my research question in previous chapter. Completely trying to link

those mathematical concepts with the classroom pedagogies, I have searched the possible ways to incorporate them in school mathematics curriculum. Concealed mathematical approaches in Newari community can be taken as bit outdated, but interesting' (Hersh, 1993, p. 14) way to perceive mathematical knowledge for the students. My finding can contribute students to understand mathematical knowledge differently rather than given process in the books.

Findings of the Study

It was great privilege for me to spent prolific time studying about traditional oil mill. During my research, I got change to know about the Newari culture more deeply than I know. I have never thought that I will get to know my own culture in a better way during the process of searching mathematical concepts in oil mill. But my focus was to explore mathematical knowledge used in traditional oil mill. While trying to answer my first research question, "How mathematical concepts are exhibited in traditional oil mill?" I was extremely delighted to get familiar with various mathematical knowledge that oil mill and Newari culture possess.

When I was school student, my teacher taught me reflection, rotation. At that time, he gave us the formula for all kind of transformation. And we students need to memorize the formula and use it in problem solving. I felt it as easy one as I need to only memorize the formula and use it with the given coordinates. At that time, I was not aware about the reflecting surface, direction and center of rotation. Teacher never tried to explain about these all. All my teacher and we students want to do was answer the question and get marks. When I started teaching, I also did same. Give formula, let students memorize it and solve the problem using formula. Later I realize that solving problem is not important, reflecting surface, direction of rotation, center of rotation these are the main important things that a student need to understand and as a

teacher, I need to teach. Once they understand these all, students can do the solution and they don't need to memorize the formula even. For this, I have explained how *'ghachha'* is helpful to demonstrate the whole process of rotation. With the help of *ghachha* we can teach students about the concept of center of rotation and direction of rotation. Also, relation between the clockwise 90° rotation and anticlockwise 270° rotation. We can show practically that these two kinds of rotation are same even the direction of rotation are different. Also it can be very useful to teach circle. The concept of circle, radius, diameter, center can teach with the help of *ghachha*.

Other parts like *gansins* can demonstrate the cuboid shape. On observing it, students can learn about the different calculation like TSA of cuboid, LSA of cuboid, Volume of cuboid. Students will get clear idea how all these calculations are done and what this calculation actual means. In addition, two *gansins* is helpful for better understanding the combine solid. Moreover, it clearly demonstrates the meaning of finding TSA for two combined solid. It will explain why the surfaces, which coincide with each other are not a part of TSA of combine solid. In my view, students will get clear idea that while finding volume of combine solid, we just add the volume of separate solid but while finding TSA, we subtract two coinciding surfaces. Once students understand this all, they easily can use their ideas on solving problems.

Another important finding of my research is the relation between the volumes of two different matters. I mean, during the extraction of oil, there I found a relation between the volume of oil extracted and volume of mustard seeds. When students see this relation in oil mill, it will be easy for a teacher to teach the relation between liters and cubic centimeter. I have experienced that most of the students get confused in cubic centimeter and liters relation and always they do wrong conversion. Once students observe the extraction of oil mill and if teacher helped them to relate with the

mathematics, then students can understand it easily and their understanding will last for long.

Similarly, I found *pau* as one of useful material to introduce the pentagon to the students. While teaching geometry, students usually as me that how this this geometry that they read in school is going to use in their daily life. I give them some examples where they use these theorems knowing or unknowing. Here in my research, I described the mathematical shape made my honeybee for storing honey. Even they don't know and even don't read about mathematics, they use mathematics in their life. We are humans and we use a lot of mathematics in our daily life. Just we need to change the way how we look into that activity. If we look through mathematical lens, then everywhere is mathematics and we can learn mathematics from anywhere. Mathematics is not rigid rather it is an incomplete and everlasting work-in-progress (Ernest, 1996). In the same way, cultural mathematics is what we do, we use, we see in our everyday life.

The incorporation of that cultural mathematics in school curriculum is challenging task to do for all. As per my second research question, "How can those mathematical concepts be contextualized in school mathematics teaching and learning approach?" and being a researcher, it is my unavoidable task to do and I think that can be done in numerous way. I have mentioned in previous chapter as well. To incorporate cultural mathematics in school curriculum, students can be allowed to solve their mathematical problems comparing with cultural mathematics. During this process, facilitator must observe and provide necessary guide to students to use cultural mathematics for easy and fun learning of mathematics. CRP is one of the best approaches to integrate cultural mathematics in classroom. Proper integration of the traditional approaches in teaching and learning mathematics can change the

perspective to see mathematics as a cultural free and pure body of knowledge (Luitel & Taylor, 2007) to culturally relevant body of knowledge. Mathematics in our curriculum is like a pure body of knowledge, which must be broken down by the use of contexts which are more subjective (Luitel, 2009). The concept of rotation, center of rotation, direction of rotation, angle of rotation can be explained demonstrate with the help of *ghachha* and we also can explain the concept of circle, radius, diameter, perpendicular lines, perpendicular bisector with the help of *ghachha*.

Conclusions

In context of Nepal, we still use traditional mathematics teaching pedagogy. Teachers go to classroom, use marker and board to teach mathematics and students were forced to do the same process of solution that teacher uses. Teaching pedagogy is completely teacher centered and students are just knowledge receiver. So, teaching and learning mathematics in traditional approach need to be changed. Ethnomathematics used in traditional oil mill can be one productive approach for teaching and learning mathematics in Nepali classroom because in a class, we teachers have to teach students from different ethnic group, with different cultural practices. Teaching and learning will be more effective when we teacher use locally available or other teaching materials to demonstrate the problem. I tried to explore and incorporate mathematical concepts used in traditional oil mills and I remained stunned to see how Newari culture and other culture in Nepal is rich in mathematical knowledge. Those knowledge always guided me to complete my research.

My research provides some practical and theoretical proofs to present the mathematical concepts use in traditional oil mills and possible ways to incorporate it in classroom for students' cognitive development and better understanding. Using ethnomathematics in classroom can address all the students in a classroom belonging

from various cultural and ethnic groups. Also, this research tried to provide necessary reasons why incorporation of cultural mathematics is important in todays' classroom for active participation of students and learning mathematics in their own cultural way.

Implications of the Study

My research aims to find the mathematical concepts used in traditional oil mills in Nepal and incorporate those concepts in our school curriculum. In present context of Nepal, we teachers, students, parents, school management all are just focusing on the marks obtained by students in exam. Students don't know how they are using this mathematical knowledge in their life. At the same time, even teachers are struggling to put forward what they are trying to say. This study could provide alternative to teachers, students, parents and school management by presenting the idea of cultural mathematics and ethnomathematics.

The basic idea of ethnomathematics is to bring mathematics which we have in our culture in learning process. Bringing cultural mathematics in classroom, students will get an opportunity to explore the hidden mathematics in their culture and they could relate the classroom mathematics with their cultural mathematics. Doing so, students tend to find fun and interesting in learning mathematics. Bringing relevant ethnomthematic in classroom is fruitful for both teachers and students. Students will explore the cultural aspects and mathematical knowledge in their culture whereas teacher himself will get change to get familiar with other cultural groups as well. Because teacher may not be from the same cultural group and at that condition, she/he need to carry out enough study before brining that cultural mathematics in teaching learning approach.

Whole world is finding the way for contextualization in mathematics teaching. This study tried to present the essentiality of the contextualization of culture in mathematic teaching process. This research will provide insight for incorporation of ethnomathemtics in our curriculum. Beside this, it aims to motivate teachers, parents, students and school management to gladly introduce their culture and ethnicity belong to them. This research aims to translate local knowledge to academic knowledge and will provide a reason to respect each other's culture.

Recommendations

I conducted my research in traditional Newari oil mill to answer my research questions. Since I conducted my research in Newari community, all my research participants were Newars and all the ideas and their perspectives they presented are a part of Newari culture. During my research, I came to know that same kind of oil mill is also in operation in other cultural group. I realized in those mills, there might be different aspects of mathematical knowledge as they belong to other ethnical groups. I explored so many mathematical ideas even inside a single room during my research, so one question hit my mind so hard that Nepal is rich in culture, and still, we teachers and students feel difficult in relating mathematics in our daily life. So, I suggest other scholar to conduct research to exploring mathematics in their culture. There is enough space to explore mathematical ideas for all level from primary to higher study of mathematic.

I request new researchers to explore more practices of ethnomathematics in their own ethnic and cultural groups. Doing so, we can put forward the mathematical knowledge in culture. When every teacher brings their cultural mathematics in mathematics classroom, students find that mathematics in not just solving and finding correct answers. When students see the mathematical aspects of their own culture,

they will fill interest in mathematics. They will feel ownership in learning mathematics.

I have expressed my opinion on incorporation of ethnomathematics in mathematics classroom. I would like to request the scholars from curriculum development committee to provide enough space incorporation of cultural mathematics in mathematics curriculum. I suggest conducting necessary survey to incorporate cultural mathematics in mathematics curriculum.

Most of all, I would like to request all the teachers to bring different local knowledge in their classroom. It is not necessary that all knowledge should be necessary. They can teach other subjects as well by bring local knowledge for better learning of their students. For this, they can start exploring local knowledge and relating it with the present curriculum and implement it in teaching and learning activities.

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APPENDIXES

तेलमिल सञ्चालकसँग सोधिने प्रश्नहरु

1) कति वर्षदेखि यो मिल सञ्चालनमा छ?
2) तपाईले सञ्चालन गर्नु भएको कति वर्ष भयो?
3) आज भन्दा पहिला कोइ शैक्षिक खोजीको लागि आएको छ यदि छ भने कस्तो खालको खोजी गर्ने प्रयास गरियो?
4) मिलमा प्रयोगमा आउने सामानहरु कहाँबाट ल्याउनुहुन्छ?
5) यो मिल कसरी बनाउनुभयो? यो बनाउने विधि कुनै स्कुल/कलेज कतैबाट सिक्नु भएको छ?
6) यसमा प्रयोग भएको वस्तुको आकारको नाम थाहा छ?
7) यो आकार कसरी बनाउनुहुन्छ? यो आकार बनाउने बिधि कतै सिक्नु भएको छ?

शिक्षक सँग सोधिने प्रश्नहरु

1) तपाईंको गणित प्रतिको धारणा कस्तो छ?
2) गणित विषयलाई एक गाह्रो विषयको रूपमा लिइन्छ के गणित साच्चैनै गाह्रो विषय हो त?
3) तपाईले गणित शिक्षण गर्दा यहाँको समुदायमा पाइने वस्तुहरूको प्रयोग गरी गणितको अवधारणा दिन सहयोग गर्छ? कसरी?
4) शिक्षण सिकाइ गर्दा कस्तो कस्तो बस्तुहरु कक्षाकोठामा प्रयोग गर्नुहुन्छ?
5) ति वस्तुहरूको प्रयोगबाट विद्यार्थीको सिकाइमा परिवर्तन आएको छ?
6) यसका विधि अपनाउँदा सिकाइको उपलब्धि कस्तो भएको पाइन्छ?