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Ethnomathematics and Cultural Project-Based Learning: Exploring Students' Experiences

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Abstract

Mathematics pervades all aspects of human life, offering valuable skills and knowledge for various activities. Encouraging students to explore mathematical concepts in their surroundings is a powerful means of fostering genuine comprehension of formal mathematics. Unfortunately, the absence of context-driven learning poses challenges for students in grasping mathematics meaningfully. This study intends to explore students' perception on the use of cultural project-based learning approach. The research involves twenty girls and ten boys from grade 9D, and two teachers participated to facilitate students in cultural project-based learning. Qualitative data are gathered through questionnaires and observations. The insights and outcomes of this research held the potential to benefit educators, trainers, and researchers in advancing meaningful mathematics instruction. Additionally, it promises to bolster project-based learning in mathematics. The ladder project notably demonstrates that students enthusiastically recognize the pervasive presence of mathematical concepts in daily life.

Keywords: *Culture, CPBL, ethnomathematics, mathematics teaching, learning mathematics*

Cultural artifacts encompass various items reflecting a society's culture, such as houses, temples, tools, clothing, art, and musical instruments, imbued with mathematical concepts (Bonotto, 2007; Pradhan, 2020). Ethnomathematics, the study of these artifacts, serves as a vital source of formal mathematical knowledge and facilitates the transmission of traditions to subsequent generations. To make mathematics education engaging and meaningful, instructors must embrace these cultural artifacts (Bishop, 1997; Pradhan & Orey, 2021). This necessitates bridging the gap between home-based and classroom mathematics, a challenge that collaboration among mathematics educators can overcome. Mathematics is a universal presence in all cultures and should be integrated into educational curricula (Brandt & Chernoff, 2015). Unfortunately, in Nepal, the current school mathematics curriculum and teacher training neglect to incorporate students' cultural practices and ethnomathematical ideas (Pradhan, 2017). This issue extends beyond Nepal, as Rosa & Gavarrete (2017) also observe a lack of consideration for students' ethnomathematical knowledge and learning approaches in school mathematics curricula. Mathematical concepts incorporated in the context of life outside of school can be learned through field observation of the learners' cultural setting. Pupils actively participate in their environmental activities, draw on their existing knowledge, and use these resources to create mathematical knowledge. The children's cultural activities included a lot of implicit mathematical concepts.

Teachers are considered one of the influential factors in educative process. Teachers' perception of ethnomathematics significantly influences their teaching methods. Teachers incorporate culturally relevant examples, making lessons more engaging and relatable when they value ethnomathematics

approach. They embrace diverse problem-solving approaches, fostering inclusivity and respecting varied mathematical backgrounds. This approach boosts student motivation and confidence, validating their existing mathematical knowledge. It also broadens perspectives, demonstrating the real-world applicability of mathematics. By recognizing and incorporating ethnomathematical practices, teachers create an inclusive learning environment that celebrates cultural diversity and promotes lifelong learning in mathematics education. To facilitate meaningful learning, the mathematical concepts inherent in cultural activities and student experiences should find a place in formal school-level mathematics curricula. This paper seeks to address the research question: "What are the students experience regarding the mathematical concepts embedded in the cultural artifacts and project-based learning approach?"

Project-Based Learning (PBL)

As Project-Based Learning is a practical and research-oriented method of teaching in which learners are engaged in creating, building and testing what they have created in collaboration with other learners; both inside and outside the classroom. However, here students get very rare chances of working outside the classroom in collaboration with their co-learners and the teachers. In the context of globalization, learners need to be equipped with the 21st century skills in order to cope with the globalized challenges but students are provided with rare opportunities to work in real life situations beyond the textbooks in the classroom.

Pearlman (2006) places a strong emphasis on critical thinking, teamwork, and content standards. Technology literacy, vocational preparation, written and spoken communication, problems solving & mathematical thinking citizenship and ethics, and oral communication are all crucial elements of education. But seldom do students participate in the development of these crucial life skills, which are necessary for success in the workplace. On the other hand, based on my observations, most Nepalese classrooms are set up according to the conventional method of teaching and learning, which leaves very little place for specialized areas like work areas, seminars, and discussions. Most of the classrooms have been packed with big number of pupils and long rows.

PBL is regarded as one of the most successful methods for meaningful, context-based mathematics education. According to Lovett et al., (2009), project-based learning (PBL) is an educational technique that gives students the freedom to research topics independently and share what they have learned in a variety of ways. Similarly, project-based education, as defined by Blank (1997), is a genuine instructional paradigm or method in which students design, carry out, and assess projects that have applications outside of the classroom. Comparably, emphasis is placed on long-term, multidisciplinary, and student-centered learning activities.

Through collaborative learning in authentic learning environments, students build knowledge, hone their presenting and communication abilities, sharpen their critical thinking abilities, and improve their teamwork and time management skills. Furthermore Grant (2002) states, "Learner-centered strategies give students the chance to investigate worthy topics in-depth and with greater autonomy" (p. 1). However, it is discovered that the majority of teaching and learning activities are still restricted to one-way lectures, in which teachers make a concerted effort to instruct in the classroom and students hardly participate in hands-on activities beyond listening to and enduring their teachers' tedious lectures. A few intelligent students do take notes and ask their teachers questions when they are unclear.

Therefore, in such traditional classroom practices, the learning outcome cannot be expected so high. Due to teacher's more activeness and students' passive learning, the learning motivation is found to be low. Our teaching curriculum is based on fixed textbooks which teachers most complete within the allocated time frame. So, while following those textbooks they limit their classroom teaching in traditional method, teaching textbooks through lecture method in pin drop silence. In other words, they hardly bother using project works even though they are essential for maximizing the learning outcomes of the learners.

Besides several challenges: lack of sufficient time, fix curriculum, lack of well trained and skilled

teachers, in using PBL in Nepalese classroom, some private as well as government funded schools have started using it as an integral part of their teaching learning practices (knowingly or unknowingly) sporadically. Additionally, PBL is thought to be an effective learning strategy in mathematics classrooms because it gives students plenty of chances to conduct in-depth research and independently create, design, and present content-related materials. It makes the most of their educational opportunities while also preserving customs and culture and imparting life skills that will aid them in the future as they build their professional careers.

Framework for the Study

Ethnomathematics-based learning is a very essential part of the development of knowledge and skills, especially for students. This reflects the diversity of cultures that can be integrated into learning. So that mathematics knowledge can be more easily understood and developed innovatively and creatively through existing cultural activities (Muhammad, et al., 2023). It is now well acknowledged in Nepal that every student offers a different combination of experiences, knowledge, and abilities to a brand-new learning environment. Numerous studies have shown that learners may build formal mathematical concepts and knowledge by using recognizable, tangible, and embedded ethnomathematical ideas and cultural artifacts. Thus, the information that children acquire outside of the classroom and that is ingrained in many cultural artifacts is acknowledged and employed as a teaching instrument to help students comprehend mathematics. The foundation of the widely accepted educational philosophy known as constructivism is the notion that students acquire information within the framework of their own experiences. Instead of focusing on students' passive acquisition of knowledge, it emphasizes their active engagement in action.

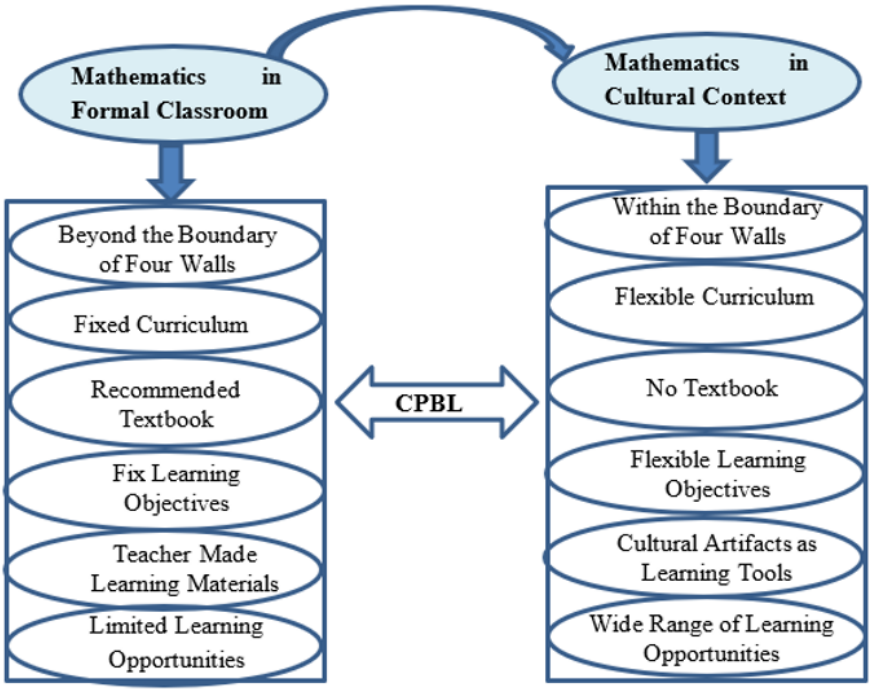
Students must undergo an apprenticeship in cognitive and social activities that are culturally particular in order to improve their ability to generate knowledge. The growing mastery of a child's cognitive growth over social agents' culturally prescribed developmental duties. According to Vygotsky (1978), knowledge's social and historical roots as well as its evolution are essential to comprehending how knowledge grows. Learners are surrounded by their parents, siblings, relatives, friends, teachers, and other classmates throughout their life. They stimulate and converse with each other. Learners lack the expertise and knowledge of parents and instructors. This paradigm makes the case that students are actively participating in the task because of their curiosity, fruitful inquiry, and cooperative learning. Through interactions with peers and adults, learners pick up knowledge about their history and culture. Shared ideas, worldviews, social interaction patterns, and language are all examples of this cultural knowledge (Borich & Tombari, 1997). Thus interaction, contextual mathematical ideas and connecting children's home mathematical ideas with formal mathematics are the best ways of meaningful mathematics learning.

The study's approach demonstrates how children's observations of cultural artifacts and ethnomathematical concepts outside of the classroom might serve as a mediated means of creating mathematical meaning. According to this theory, students acquire and apply mathematical ideas and concepts in two separate contexts: inside the classroom and outside its four walls. Both within and outside of the classroom, there are several goals associated with studying mathematics. Children often study mathematics in the classroom in order to pass or score well on exams; yet, they have implicitly practiced mathematical concepts in non-school settings in order to go about their everyday lives (Pradhan & Orey, 2021). Even the methodology used by teachers is mostly a guided model of the test.

The claim, we make in this study is that the cultural context of children in Nepal is a rich environment that can generate and distribute mathematical knowledge. This viewpoint emphasizes how cultural artifacts may be useful in organizing various mathematical ideas and information. Through careful observation of cultural artifacts in out-of-school settings, students can uncover a multitude of mathematical concepts and information concealed within them. In this framework, children are not bounded in predetermined curriculum objectives and textbook issues under this system. They are engaged in real-world problems embedded in cultural artifacts.

Figure 1

Framework for Cultural Project-Based Learing in Mathematics



They are working on issues that are part of the outside-of-school world. The main justifications for using CPBL are that it increases learners' motivation and encourages cognitive engagement. Cultural Project-Based Learning (CPBL) connects students' out-of-school mathematical ideas and knowledge with school mathematics (Pradhan & Orey, 2021). Thus, CPBL is one of the culturally relevant strategies for teaching mathematics. It provides a wide range of learning opportunities for students and creates a collaborative learning environment. In contrast to learning through didactic instruction, this concept contends that students will learn more and retain it better if they are motivated and intellectually engaged. With this framework, we hope to shift educational practice from a traditional to a project-based methodology. Additionally, it is said that this approach improves mathematical concepts and ideas in relevant and efficient ways for both teaching and learning.

Method and Procedures

The purpose of this study was to investigate how mathematical concepts are ingrained in cultural artifacts and how students see the use of an ethnomathematical approach to the teaching and learning of mathematics in the classroom. The goal of the ethnomathematical method is to help students develop mathematical ideas by utilizing their sociocultural environment. We firmly positioned ourselves as qualitative researchers in order to accomplish our study goals. To characterize, decipher, and illuminate the significance of cultural practices with respect to ethnomathematical concepts ingrained in cultural artifacts, we employ ethnographic instruments. We continually address interesting topics related to mathematical concepts included into the creation of cultural artifacts and their application to the teaching and learning of mathematics in schools while carrying out this study.

Selection of Study Location

This study was conducted in Padmodaya Public Model Secondary School, one of the reputed schools in the Dang District of Nepal. The school was selected as study location because the teachers were eager to incorporate an ethnomathematics approach in their teaching and were willing to participate voluntarily in the research project.

Selection of Student Participants

There are more than 300 students in Grade IX, and they are divided into ten sections. Among them, five sections offer major mathematics. As this study aimed to integrate ethnomathematical ideas with concepts in major mathematics (Optional Mathematics), we randomly selected section D from the five sections offering major mathematics. Thirty students from section D, comprising 10 boys and

20 girls were participated of this research. Additionally, two mathematics teachers who teach optional mathematics, were selected to support students' collaborative work through a cultural project-based learning approach.

Guide Line to the Students

Prior to entering the study area, the researchers invited the student participants to investigate the mathematical concepts that may be found inside the ladder project. We created the Student Guideline to help the students make the connection between classroom mathematics and real-world scenarios. This task, which took around two hours, was done prior to field trips.

Tools and Materials for the Ladder Project

Each group was equipped with measuring tape, a protractor, a ladder, paper, and pencils for their exploration and verification of mathematical properties.

Formation of Collaborative Groups

The students were divided into three heterogeneous groups, ensuring a mix of genders and academic abilities to facilitate collaborative learning. Two teachers guided two groups A and B, and second author supported the remaining one C. Each group was equipped with measuring tape, a protractor, a ladder, paper, and pencils for their exploration and verification of mathematical properties. The field trip was carefully planned, with teachers guiding students in the ladder project, while first author played a supervisory role, offering guidance and feedback as needed. Data collection involved a combination of observation and questionnaires. First author closely observed all student and teacher activities during the ladder project, and distributed separate questionnaires to all three groups.

Data Management

The data analysis process involves collecting responses from both teachers and students regarding their perceptions of using project-based learning and incorporating ethnomathematics in teaching and learning school mathematics. The gathered data is systematically organized, coded, and categorized to identify recurring themes, allowing for a comprehensive understanding of the participants' views. Finally, analysis is conducted to highlight in the perspectives of teachers and students on the use of cultural project-based teaching and learning approach.

Ethical Considerations

Ethical research practices were strictly followed in this study. Before interviews and observations, informed consent was obtained from all participants. The images in this study are published with the full consent of research participants i.e., students and teachers. They were informed about the purpose of using their images, and they voluntarily agreed to allow their photographs to be used for dissemination of research outcomes.

Findings and Discussion

Students' Experience on Cultural Project-Based Learning

Every student found learning mathematics through a field trip technique to be the most appealing. Due to the fact that each student participated in various activities independently while combining their learning, this method enables students to study in groups. During the field visit, it was observed that students were actively engaged in the learning process. Some of them were recording measurements of length of ladder, distance between ladder and wall, and others were analyzing the collected data, and some were comparing the results to come to conclusions.

Figure 2

Engaging in the Ladder Project

They had asked to write a reflection on the basis of the field trip approach and mathematical ideas developed on them. Regarding this, group A expressed as:

> We did not learn only practical knowledge and skills of mathematics from ladder project. We also learned about cooperative and collaborative learning and, also got ideas about how to make modeling of mathematical ideas. Mathematical ideas we learned at school mathematics curriculum, we have already used these concepts *unknowingly.* From this project work we realized it.

Through the ladder project, students have gained practical knowledge and skills in trigonometric ratios as well as the socialization process. In addition, they have learned to give a pictorial representation of mathematical concepts, which is a very important way of learning mathematics. Other participants also presented similar answers. Further they have learned mathematics is everywhere and used in our daily life. Group B expressed their common voice as:

> If we chat about ourselves, then why we can't? We can do even better than that, just need project work like this based on real-life experiences. So we think that this kind of project work should be conducted frequently. Such kinds of project works should be conducted in other subjects too. "Frankly speaking, the things that we use, see, eat, wear, and even our cultural arts; religious designs, etc. are founded on mathematical ideas. Thus, we shouldn't be surprised to simply say that Mathematical concepts are everywhere, so there is on the ladder as well. Overall, this work helped us to understand and learn mathematical concepts there thoroughly in a simple way. Therefore, the observation helped us to understand mathematics concretely and us to believe that mathematics is everywhere.

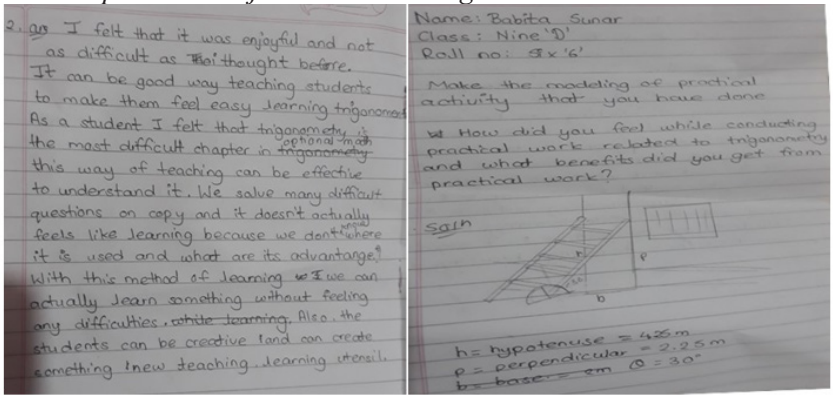
From my observation, when we told students about Ladder Project for trigonometric ratios, we found they all cheered with smiles and the bride's face. Furthermore, students have increased their belief in project-based learning via the ladder project for conceptual mathematics learning, and they have learned to preserve their traditions and connect them with formal mathematics. They gave more values to project for learning mathematics. Similarly, the common voices of group C were:

> It was such an amazing experience for us while conducting the practical work related to trigonometry. When our session was going on, we used to ask the question like our whole mind was stuck in the question, why is this important to read? What could be its use in real life? etc. we also used to watch YouTube videos on trigonometry, as we were told that they used it in the engineering field, but we felt like, no, we are not satisfied with this answer. We were so confused and stuck on that question. But after doing this practically with the help of a ladder, we were truly satisfied, like no one needed to answer the question; the answer just flew by itself, and we felt delighted. If mathematics is taught in this practical way, we think no one can ever say that mathematics is our dislike subject.

From the voice of group C, it was noticed that before that ladder project, they were studying mathematics to pass the exam by force. They did not know the practical aspects of trigonometry. In this project work, they used their hands, heads, and hearts to learn mathematics, so they became happy, understood the use of mathematics in real-life situations, and began to love this subject and respect their mathematics teacher too.

Figure 3

Students Perception on Project-Based Learing



From the interview with the students, we found that they agreed the artisans who developed arts and artefacts centuries ago possessed implicit mathematical knowledge**.** Thus, mathematics can be viewed as a cultural phenomenon**.** The CPBL approach helps connect the learners' cultural capital with the teaching and learning of school mathematics (Pradhan & Orey, 2021). Learners construct mathematical knowledge based on their experiences and interactions with peers. Connecting students' familiar contexts to the process of teaching mathematical content provides rich learning opportunities. There are many elements in the out-of-school environment that can be linked to the teaching and learning of mathematics. The historically accumulated and culturally developed bodies of knowledge and skills essential for household functioning and well-being (Moll, Amanti, Neff & Gonzalez, 2005) refer to the learners' funds of knowledge**.** These funds of knowledge, along with children's everyday activities and life experiences related to mathematical ideas, serve as powerful tools in the teaching and learning process. The mathematical ideas embedded in children's everyday household activities offer opportunities to learn school mathematics. From our field observations and throughout every stage of data collection with the student participants, the CPBL approach provided opportunities for learners to construct mathematical knowledge. Through this approach, students were motivated, engaged, and happy**,** as they actively participated in field-based learning. They reported that the CPBL approach was interesting and made learning enjoyable.

Conclusion

Students were given a high learning environment that made them discover mathematical concepts by providing diverse tasks during teaching and learning through certain cultural activities. So, learners construct their mathematical ideas through active participation in their social context. In this way, social interaction and collaboration are primary tasks while constructing new knowledge. The study of mathematical ideas found in the ladder project helps to create ample opportunity to develop mathematical knowledge beyond the four walls of a classroom. The project-based learning approach can be used as a pedagogical tool for the teaching and learning of mathematics. Their report shows that they had used empirical knowledge to solve the mathematical problem of finding the height of walls of building. The project-based learning approach provides students with the opportunity to learn mathematics in their own way and to develop mathematical ideas without the textbook and outside the classroom. This approach undoubtedly contributes to the methodological empowerment of teachers in their teaching practice.

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