ENVISIONING ENGAGED MATHEMATICS PEDAGOGY THROUGH PROJECT-BASED LEARNING FOR NEPALI SCHOOLS: AN AUTOETHNOGRAPHIC ACTION INQUIRY

Ram Raja Thakuri

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DECLARATION

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

…….. January 13, 2023

Ram Raja Thakuri

Degree Candidate

DEDICATION

This dissertation is dedicated:

To my parents (father, late Krishna Bahadur Thakuri, and mother Pampha Thakuri) whose honesty, dedication, value-based lifestyle and efforts to my education have been guiding my educational journey.

To my wife, Parbati Kunwar Thakuri, whose encouragement, continuous love, care and support empowered me to complete this scholar work with full excitement.

To my beloved daughter, Prisha Thakuri, whose love, support and indirect pressure inspired me up to the ending of the journey.

To my dearest student, Dikshya Neupane, whose care, support and constructive effort encouraged me to end the journey.

To all the known and unknown teachers, philosophers and researchers whose ideas, knowledge and wisdom have played a creative role in making the journey meaningful.

This dissertation entiled *Envisioning Engaged Mathematics Pedagogy through Project-Based Learning for Nepali Schools: An Autoethnographic Action Inquiry* presented by *Ram Raja Thakuri* on *January 13, 2023.*

APPROVED BY

…… January 13, 2023

Asst. Prof. Binod Prasad Pant

Acting Head of Department

…… January 13, 2023

Prof. Bed Raj Acharya, PhD

External Examiner

…… January 13, 2023

Prof. Bal Chandra Luitel, PhD

Dean/Chair, Research Committee/Dissertation Supervisor

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 readers upon request for scholarly purposes.

…… January 13, 2023

Ram Raja Thakuri,

Degree Candidate

ABSTRACT

of the dissertation of *Ram Raja Thakuri* for the degree of *Master of Philosophy in STEAM Education*, presented on January 13, 2023.

Title: *Envisioning Engaged Mathematics Pedagogy through Project-Based Learning for Nepali Schools: An Autoethnographic Action Inquiry*

Abstract Approved: …….

Prof. Bal Chandra Luitel, PhD

Dissertation Supervisor

This dissertation portrays the learning environment of different classes and levels based on my lived experience of the learning world, my professional practice and my visions in applying project-based pedagogy to promoting engaged mathematics learning through the STEAM project. Moreover, it depicts the pedagogical shift from one-way teacher-centered teaching and learning to student-centered, inspired by the idea generated from my MPhil journey in STEAM education.

I have generated my research problem from conceptual, contextual and empirical perspectives experiencing the ongoing process of mathematics teaching and learning from the early classes. In this regard of completing the inquiry, I designed a principal research question with four subsidiary research questions. Also, I employed a multi-paradigmatic research design space including three research paradigms: interpretivism, criticalism and postmodernism for the successful inquiry.

Likewise, I used autoethnographic action inquiry as the methodology. Autoethnography is employed to express my lived experience as a mathematics

learner, teacher and teacher educator. I performed my narratives employing poems, dialogue, monologue and stories. Besides, inside autoethnography, I used action inquiry to transform my professional practices by means of STEAM project implementation in my daily classroom activities. For this inquiry process, I was guided mainly by two grand theories, constructivism learning theory and transformative learning theory.

I unpacked my narratives, plan, implementation of the plan and its reflection with the development of four sections. In the first section, I explored my lived experiences from early school education to my master's degree in learning mathematics, including the experience of MPhil level in STEAM education. Moreover, I critically reflected on my learning experience, professional practices and even the turning point of professional practices toward transformation to address the first research question as well.

In the second section, I presented my in-depth plan for completing the inquiry to respond second research question. In addition, I envisaged my STEAM project promoting engaged learning in order to encounter disengaged and decontextualized learning of mathematics. Also, I included the overall framework of STEAM project and its design by establishing the connection between STEAM disciplines in this section.

The third section presents the implementation of STEAM project in classroom practices. Moreover, I unpacked the overall activities of the project application in learning mathematics with the challenges I faced during the implementation. The third section was devoted to answering the third research question indirectly.

Similarly, I developed the fourth section to reflect the project implementation outcomes from my and the participants' sides. Based on the lived experiences of

project-based mathematics learning, I shared the ideas created by participants and myself in this section to address the fourth research question.

Finally, from this autoethnographic action inquiry, I found myself as the change agent from learning as well as professional perspectives for promoting engaged learning to the students as I faced the existing mathematics learning process is bringing many barriers in learning on the one hand. On the other hand, I found that project-based learning is the best approach to developing the vision of an engaged and contextualized mathematics learning process. Thus, this inquiry has become a valuable achievement for me in my professional life. Besides, this might inspire others for their transformative professional journey from the perspective of promoting engaged learning and designing vision in teaching and learning mathematics.

…… January 13, 2023

Ram Raja Thakuri,

Degree Candidate

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I would like to express my sincere gratitude to my dissertation supervisor, Prof. Bal Chandra Luitel, PhD, for his continuous encouragement, care, support, inspiration, worthy constructive comments and feedback throughout this study. I am sure that without it, this dissertation would not be in this form. I deeply appreciate his transformative ideas and responses, which empowered and promoted me to complete this inquiry. From his guidance, I got the idea of shifting my pedagogical practices to what I expected in my professional journey. Indeed, it is not sufficient for him what he has been for me during this inquiry.

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I am thankful to the University Grants Commission (UGC), Sanothimi, Bhaktapur, Nepal, for granting me MPhil Research Support Scholarship, which supported me to complete my MPhil journey.

I am extremely grateful to all the teachers and facilitators during my MPhil journey who motivated and encouraged me to be critical and reflective in many ways. It supported me in coming out from conventional ways of professional practice. Also,

it empowered me to challenge my comfort zone as a mathematics teacher and mathematics educator.

I am thankful to the department of STEAM Education, Kathmandu University School of Education and KUSOED family for supporting and providing a suitable learning environment to complete this inquiry.

I am also thankful to my life partner Parbati, for her enduring support, love and care, and to my daughters, Prisha and Roshika, for supporting and assisting me directly and indirectly.

My words are not sufficient to thank my research participants, who contributed directly being involved in my inquiry and made my work successful.

Finally, I am thankful to all my teachers, friends and all well-wishers, who directly or indirectly encouraged and supported me to conduct and complete this inquiry from beginning to the ending.

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Ram Raja Thakuri,

Degree Candidate

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ABBREVIATIONS

ABMI	Activity-Based Mathematics Instruction
AEAR	Autoethnographic Action Research
AD	Anno Domini
B. Ed.	Bachelor in Education
CDC	Curriculum Development Center
COVID	Coronavirus Disease
CSE	Computational Science Education
CT	Computational Thinking
EEE	Engineering Education Epistemology
ESD	Education for Sustainable Development
FGD	Focus Group Discussion
ICT	Information and Communication Technology
I. Ed.	Intermediate in Education
KU	Kathmandu University
KUSOED	Kathmandu University School of Education
M. Ed.	Master’s in Education
MOE	Ministry of Education
MPhil	Master of Philosophy
NCF	National Curriculum Framework
NGSS	Next Generation Science Standards
PBL	Project-Based Learning
PCL	Proficiency Certificate Level
PhD	Doctor of Philosophy

SLC	School Level Certificate
STEAM	Science, Technology, Engineering, Arts and Mathematics
STEM	Science, Technology, Engineering, and Mathematics
TL	Transformative Learning
TLLM	Teach Less, Learn More
TPD	Teacher Professional Development
VLE	Virtual Learning Environment

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CHAPTER I

INTRODUCTION

I have explored my lived experience of the disengaged and decontextualized mathematics learning journey under formal education from primary level to master's degree through this chapter. Next, I have explored the experience of engaged learning at the MPhil level at Kathmandu University. To be precise, I have submitted some arguments for birthing my research topic through this chapter.

Moreover, the chapter includes the concept of project-based learning (PBL) incorporating STEAM (Science, Technology, Engineering, Arts and Mathematics) based projects and its major aspects in education. For this, I have consulted the ideas of many authors in the sense of enriching my argument. Likewise, I have submitted the conceptual, contextual and empirical evidence behind selecting the research topic. Moreover, I have included research purposes to explore my study interests and ideas. Likewise, I have mentioned principal research questions and corresponding subsidiary research questions to generate the research work to derive meaningful desired conclusions. Furthermore, the significance of the study is included in this section from the standpoint of applying the findings of the investigation. Meanwhile, this chapter provides the study's limitations as a bridge to the next chapter, and a chapter summary.

Setting the Scene

In my local context, a person was judged to be successful when they secured

excellent scores in the summative written examination[1] of certain hours and got a good job with an attractive salary after getting the certificates of certain standard classes. Therefore, my learning journey from the beginning of formal education was directly affected by this concept as well. Moreover, while I was at the primary level from 1991 to 1995, my major priority was to get an excellent score in the final examination of grade -5. In the lower secondary level from 1996 to 1998, the major focus was to pass the final examination of grade 8 with excellent scores. Likewise, the overall efforts of school-level education from 1991 to 2000 were devoted to get excellent achievement in the School Level Certificate (SLC) examination, which was taken as an '*iron gate*'[2] in my context. I passed the SLC examination in 2000 with good scores in the first division as the demand of my family, school and even society, i.e., my local context. Thus, I passed my school-level education by achieving excellent scores in mathematics by following the one-way instruction of my subject teachers. It means I was talented in my academic journey in their view as well.

After passing SLC in 2000, I got admission to I. Ed. with a major in mathematics subject at a campus in Kathmandu valley. I completed my I. Ed. in 2002, B. Ed. in 2005, and M. Ed. in 2008 from the same campus where I received my university education with mathematics as a major subject. As a whole, my performance was good in following the guidance and instruction of the subject teachers and getting good scores in all levels (see chapter IV). However, I was not

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[1] The examination in our culture which taken to upgrade from one class to other is known as summative examination.

[2] Iron gate means SLC was taken as very difficult to pass.

satisfied with the learning technique as I was devoted to learning and remembering the concepts using the parrot learning technique.

Indeed, the knowledge of mathematics is essential for almost everyone in the present society due to its use in the multi-sectors such as office, business and finance and even in the decision-making of the individual. Therefore, it is taken as the core subject of our education system. Likewise, it creates a foundation for understanding science, engineering, technology, economics, and other disciplines. Though it is supposed to be an applicable subject in different disciplines and practical life, students face many problems. As per my lived experience from primary level to Master's degree, I can say that very often, teachers are bound to follow the methods that are illustrated in the textbooks. Besides, our culture of learning is based on memorizing, practicing and then test of the content mentioned in the syllabus using the various examinations of certain hours, giving credit to the right solutions (Amirali & Halai, 2010) rather than empowering students in engaged learning[3].

I felt from my learning that most of the teachers delivered more and more lectures in *one size fits all*[4] techniques and paid less attention to the active participation of the students in the learning process. As a result, we students were compulsion to memorize the mathematical concepts instead of understanding them meaningfully through projects, group work, discussion and collaboration, and feeling tedious. We become passive listeners and receivers because teacher-centered practices

[3] The learning technique which promotes students' active participation in learning is known as engaged learning.

[4] One size fits all is meant treating all in the same way.

are like one-way traffic instruction[5] (Freire, 1970), where our teachers become active in delivering content to us.

My learning techniques were strongly influenced by content-based and examination-driven practices, in which less attention was paid to promoting students' engagement in solving real-world problems using knowledge and skills. Luitel and Taylor (2005) noted that the teaching culture appears to be depositing teachers' ideas into students. My teachers were also trying to deposit the mathematical contents in traditional one-way *chalk and talk*[6] methods during my mathematics learning journey from school to master's degree level.

In truth, teaching-learning techniques in most of the classrooms were to be more lectures dominated and disengaged (Dhakal & Sharma, 2016). We students did not get the environment of group discussion and collaboration, i.e., there was no sense of engaged learning in classroom practices. However, the main motto of engaged learning in mathematics is '*Teach Less, Learn More*[7] *(TLLM).'* Engaged learning focuses on student-centered learning by engaging them internally with hearts and minds focusing on their deep understanding rather than teaching them more content from the conventional pedagogical technique.

According to the Ministry of Education (2005) of Singapore, TLLM is about "teaching better, to engage the learners and prepare them for life, rather than teaching more, for tests and examinations" (p. 5). Indeed, engaged learning means "a deeper

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[5] Only teachers are actively teaching for students as like one-way traffic (Freire, 1970)

[6] Chalk and talk method represent a method of teaching mathematics in conventional teaching methods.

[7] Teach less learn more is a method of teaching mathematics in engaged learning techniques.

student relationship with classroom work" (Fair Go Team NSW Department of Education and Training, 2006, p. 9), which was beyond my learning practices till my Master's degree. Indeed, the teacher is assumed to be capable based on the pedagogical practices they use in the classroom (Umoren, 2001). Therefore, the defective pedagogical approach cannot empower students academically as well that I experienced from my learning journey.

Furthermore, engaged learning empowers learners to learn content by connecting it with their society and local context. Indeed, "The view of learning as becoming more adept at participating in distributed cognitive systems focuses on engagement that maintains a person's interpersonal relations and identity in communities in which the person participates" (Greeno et al., 1996, p. 26). Students need encouragement, guidance, and support from the learning environment, which was beyond my learning scenario.

With the rapid economic, social, scientific and technological developments, students need to be raised to gain twenty-first century skills such as creativity and innovativeness, critical thinking, problem-solving, and decision-making skills. Learning approaches in formal education must be revised by keeping students at the center to equip students with such skills and make them successful in solving real-world problems. Keeping such ideology in mind, I enrolled in the course STEAM[8] (Science, Technology, Engineering, Arts and Mathematics) education of MPhil under Kathmandu University, School of Education in February 2019 with the hope of transformation.

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[8] STEAM represents multidisciplinary pedagogy with the connection of science, technology, engineering, arts and mathematics

I got a fully engaged learning environment in the classroom. Our teachers facilitated and empowered us to actively do our activities as a learning process. We were motivated to interact, collaborate, create and critically reflect on our own idea. We consulted many authors' ideas to strengthen our ideas of learning. We were inspired to apply many engaged learning tools at the time of teaching and learning. From such a learning scenario, I arrived at one decision that the implication of project-based learning[9] can be an effective means among many such engaged learning ways.

Moreover, I felt from my learning experience at this level that engaged learning through project-based learning primarily focuses on the learning process and encourages students to solve daily life problems (Kokotsaki, 2016). A concrete artefact that represents the end product of learning gained from project-based learning is the uniqueness of this type of learning (Helle et al., 2006). In addition, the concrete artefact in learning is represented using photographs, reports, videos, sketches, models and other collections that foster students' new understanding, knowledge and attitudes in learning mathematics (Holubova, 2008). Such kind of participation of the learners fosters deep learning. As a result, learning becomes fruitful from the perspectives of products. Also, students can use such learning experiences and ideas to solve real-world problems. Thus, I am convinced that project-based learning fosters the self-regulation of the learners promoting their conceptual understanding and knowledge by means of a systematic process of documentation and reflection in the learning journey (Barak, 2012), which stands in opposition to the conventional mode of learning that treats teacher as "the transmitter of the knowledge" and the learners as

[9] Project-based learning (PBL) is the learning technique by means of using related projects.

"the receptor of the information[10]" (Guo et al., 2020) as I experienced from my learning journey.

In addition, among many early proponents of project-based learning, John Dewey contributed to developing the concept of project-based learning with the idea of 'learning by doing' (Bender, 2012). With the vision of enriching the concept, Dewey argued that the teacher should work as the facilitator in school rather than only imposing certain ideas or forming certain habits in the students. Likewise, Piaget advocated the idea of project-based learning, which focuses on the learners' engagement in invention and viewing learning as a process rather than memorization and acquiring knowledge (Sarrazin, 2018). It was the learning environment of my expectation during my learning journey. However, I was forced to receive the content knowledge from my subject teachers. Regarding project-based learning Thomas Markham (2011) clarified that

> *PBL integrates knowing and doing. Students learn knowledge and elements of the core curriculum but also apply what they know to solve authentic problems and produce results that matter. PBL students take advantage of digital tools to produce high-quality, collaborative products. PBL refocuses education on the student, not the curriculum—a shift mandated by the global world, which rewards intangible assets such as drive, passion, creativity, empathy, and resiliency. These cannot be taught out of a textbook but must be activated through experience.* (p. 39)

Thus, PBL emphasizes such learning procedures that focus on the students' interest and stimulate them for deep thinking since they engage in acquiring and

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[10] Teacher is the supreme person who works as a knowledge transmitter and students are receptors.

applying new knowledge in solving real-world problems. Furthermore, PBL creates the opportunity for the students to signify the problems and the challenges behind them with its real-world applications that strengthen the skills of problem-solving and conceptual understanding (Crane, 2009). Next, it encourages student-centered learning activities, making it interdisciplinary and multidisciplinary such that learning becomes long-term memorable. Also, for learning mathematics through PBL, students need to plan and organize their own activities and share their ideas in a project-based class rather than in teacher-led classroom activities like traditional instructional techniques. The major feature of this learning technique is an emphasis on students' collaboration in learning or creating individual artifacts to explore the ideas they learned.

Practically, it seems that PBL replaces other conventional instructional approaches, such as the lecture method and textbook-driven teacher-centric pedagogies at the time of learning mathematics. Furthermore, it encourages teachers to assist the students with an in-depth understanding of the concepts rather than delivering surficial information. It follows that PBL supports students to achieve problem-solving skills as well as creative skills for an in-depth understanding of key concepts. It helps them mastery of 21st-century learning skills[11] such as critical thinking, problem-solving, collaboration, and different interaction techniques in the learning process so that they can easily solve their daily life problems. As a result, students work as the researchers and assessors of their own learning and identify the outcomes themselves while learning from the project-making technique.

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[11] Interactions, collaboration, problem solving skills, and critical thinking are known as commonly 21st century skills.

To boost the students to gain 21st-century skills in solving real-world problems, it is obvious that an isolated knowledge of a separate subject may be incomplete and insufficient as the disciplinary concepts are interlinked with each other. Therefore, I have preferred to focus on interdisciplinary and multidisciplinary project-based learning in mathematics that links the different disciplines with students' engagement instead of teaching the concepts of different disciplines independently and separately. In such a learning environment, students are engaged in constructing the knowledge for solving real-world problems under the supervision of the teachers (Guo et al., 2020). One such learning technique can be project-based learning based on STEAM education. Indeed, the learning pedagogy STEAM originated from STEM (Science, Technology, Engineering and Mathematics) by adding one discipline: art.

It seems that the origin of the STEM curriculum stemmed from America from the perspective of job opportunities for economic empowerment. However, STEAM education nowadays is taken as an education movement in the process of educating people in many countries (Liao, 2019). It is accepted as the appropriate educational pedagogy to prepare students with 21st-century skills and increase academic achievements (Hau et al., 2020) in mathematics. By considering that STEM is not enough for the learners to develop creative and critical thinking skills, the arts (A) is added to form STEAM with the purpose of learning improvement, creativity development with a creative mindset, and increasing potentiality for success to the learners (Hau et al., 2020) in one hand. On the other hand, the integration of arts encourages educators to provide more opportunities to learners to make them success in their future life, in their professional world and even in problem-solving situations while learning mathematics. Therefore, I believe that integrating arts into learning

makes learning more interesting and fun and keeps learners more engaged in their duties devoted to learning. Due to the mind-blowing impact of STEAM education with the integration of arts, a number of schools in many countries are incorporating such pedagogical approaches.

Such integrated learning allows students to understand the world as a whole rather than isolated disciplinary knowledge in science, technology, engineering, arts and mathematics. As a result, students become able to solve their real-life problems themselves from the connection of ideas of different disciplines.

In my opinion, using the STEAM project is simply a way of making learners understand the content in their engagement and applying an integrated form of learning that resembles real life. STEAM projects assist students in learning mathematics by connecting the ideas of other subjects such as science, Nepali, social studies, technology, and arts. Thus, I ensured that using STEAM projects in mathematics classrooms helps students develop crucial skills, such as efficient communication, problem-solving, innovation, critical thinking and creativity. Also, the project empowers students in analytical and creative thinking during learning. As a result, it supports them to be more well-rounded and enhances them to grab opportunities in the future.

In our context, the transformation of educating process seems still at the beginning stage from the STEAM perspective. Moreover, change in education policy, revision of curriculum and development of textbooks based on it for more integrated and transdisciplinary form is in process in Nepal (Belbase, 2019). However, we cannot find the perfect planning and preparation for STEAM education unpacked in the curriculum framework. The sense of such educational transformation can be seen in the attempt (CDC, 2007) made by focusing on an integrated education at the school

level in Nepal (Belbase, 2019).In the framework, it is emphasized to apply an integrated curriculum for grades one-three (CDC Nepal, 2007). The Curriculum Development Center (CDC) of Nepal has initiated an integrated curriculum and related textbooks for grades one to three. Moreover, the curriculum is implemented up to grade three from the academic year 2078.

Moreover, to enrich the concept of integrated and multidisciplinary transformation in education, the government has started a school reform project to develop ICT-guided and child-centered pedagogical activities in all schools (MOE, 2007) in one hand. On the other hand, National Curriculum Framework (2007) has initiated the integrated curriculum from the first phase (grade 1-3) of basic level school education with the objectives: “to give children the opportunity to be introduced with formal education and basic literacy, mathematical knowledge and life skills and develop the habit of personal health and hygiene” (p.43). The main expectations of this curriculum are that students become well known with their surroundings and get opportunities as they need to learn even in their mother tongue.

In addition, as the tiny effort made regarding modern pedagogic practice gradually in our country, the National education plan includes the “School Sector Reform Plan 2009–2015” (MOE, 2009) and the “ICT in Education Master Plan 2013–2017” (MOE, 2013). The goal of using Information and Communication Technology (ICT) is to keep teachers updated on the most recent pedagogical practices. However, it is not found in practice with appropriate management and organization in all of the country's schools.

Thus, some efforts have been made to empower integrated multidisciplinary STEAM learning approaches in the education system in our context in recent years. But the teaching and learning practices still guided by teachers dominated the

environment with students' passive presence in the *yes method*[12]. There is no sense of a STEAM learning environment while talking about overall instructional approaches existing in our practices within schools' and colleges' classrooms. However, some educational institutions have started the concept of an integrated curriculum at the school and college levels. As part of the National Curriculum Framework (2007) plan, all schools have started to implement integrated curricula up to grade two. A tiny effort is found in the design of the curriculum of this level, but due to the absence of appropriate management in the sense of teachers' training, concepts of integration, knowledge of integrated curriculum and its application in addressing the problems of daily life.

Indeed, running a mathematics classroom daily by using STEAM-based projects seems more effective and practical since the projects not only play a positive role in encouraging students towards learning (Lee et al., 2013) but also engage students in transformative learning. In addition, using STEAM projects in mathematics classrooms, learners study mathematics concepts through the support of many disciplines with their direct engagement. Therefore, I have chosen the research topic "Envisioning Engaged Mathematics Pedagogy through Project-Based Learning for Nepali Schools: An Autoethnographic Action Inquiry" with the hope that the projects can be one of the best ways of teaching and learning mathematics by engaging students.

Project-Based Learning in My Research

According to my research under this subsection, I have explored the exact meaning of project-based learning in teaching and learning mathematics. As a student

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[12] Yes method means blindly accepting the ideas of the teachers in learning.

of different levels treated by conventional learning environments and then as the teacher practitioner, I have shared my ideas of dissatisfaction towards the practices, which seems directly or indirectly in this dissertation. However, my effort through this research is to empower engaged learning in mathematics in the classroom rather than providing information about content such that students could get the learning environment of their interest. In addition, I have explored what a project in my research is meant in teaching and learning mathematics, and I have indirectly mentioned the causes of choosing it in my inquiry.

Indeed, STEAM pedagogical practice in learning mathematics is a type of integrated and interdisciplinary pedagogy that links the concept of mathematics with other disciplines so that students are encouraged for a deep and meaningful understanding of real-world problems and makes them capable of solving them. With the implementation of this approach, the knowledge of different disciplines such as science, mathematics, engineering and technology are incorporated into creativity and artistically (Pant et al., 2020) to solve real-world problems. Therefore, the chance of problem-solving becomes high in the learners' participation in this technique.

Likewise, enabling students to face 21st-century problems requires enriching and empowering them from holistic perspectives by taking seriously past, present and future based on their needs, interest and opportunities locally and globally (Hau et al., 2020). For this, STEAM pedagogy seems to be one of the alternative learning approaches. In this approach, students learn and apply their own knowledge from their own level of understanding in their own context and connect it gradually to disciplinary learning using projects.

Furthermore, they are helped through STEAM knowledge and skills by integrating and complementing not only to understand the principles but also to

enable them in practicing and creating products in everyday life (Hau et al., 2020). While applying STEAM projects in mathematics classrooms, students are equipped to explore their passions, interests, experiences and talents to make them skillful individually. With these advances in STEAM pedagogy, I believe that it helps to educate students from an overall perspective and encourages them to be global citizens in their societies.

Moreover, STEAM pedagogy provides tools and methods to students to explore new and creative ways of problem-solving relating to multiple fields such as science, technology, engineering, arts and mathematics. Besides, it empowers us for an in-depth understanding of problems, innovation of recent ideas and cohesive education practices in the classroom. However, there is a big challenging task to apply STEAM pedagogy practically at the school in our context. For this, it seems essential to revise our education policy, curriculum, curriculum implementation ways, visions towards education etc.

By experiencing the nature of learning through STEAM pedagogy, I ensured that the students were engaged in learning rather than in the role of the audience (Segarra et al., 2018) through STEAM learning with the help of projects establishing interdisciplinary relationships between different disciplines. If it could be possible to interlink the concepts of many disciplines to the concept of any one discipline, the disciplinary concepts become more fruitful, long-lasting and applicable in real-life situations. In common understanding, learning mathematics incorporating the concepts of science, technology, engineering, arts and mathematics signifies the meaning of applying STEAM projects. However, in my research study, STEAM projects do not compulsorily include the concepts of all disciplines. I felt many unavoidable obstacles, such as education policy, curriculum design, course design,

disciplinary content selection, time boundary for the course, existing instructional practices within educational institutions and even the knowledge of integration to the researcher etc.

Although team efforts and cooperation are taken as the important parts of STEAM project- based learning, it does not require the students to do hardworking in the development of the project constantly. As the demand of projects in my research also, they can work alone to investigate and create at their own pace and idea and then have to share their work and conclusions among their friends. Likewise, during the implementation of the projects, their learning also can be assisted and empowered by informal learning outside of the school premises. With such a mindset, I have designed the STEAM projects for mathematics teaching in my research by incorporating the concepts of at least one other discipline among science, technology, engineering and arts rather than teaching mathematics as an isolated subject. Thus, I have designed the project to empower classroom activities that enrich engaged learning by linking at least one other discipline. I have designed the project as a facilitator to work with students in organizing meaningful tasks, fostering gained knowledge and problem-solving skills to enrich their learning achievement.

Statement of the Research Problem

The problem of my research was generated mainly based on three criteria: contextually, conceptually and empirically.

Contextually

While talking about the existing curriculum of our context is generally prepared by a few experts based on their understanding. It is reduced into a high in a structural form beyond the social, cultural and local context. Such a curriculum is unable to address real-life problems. In addition, mathematics, science, engineering,

arts, technology etc., are taken as separate disciplines without connecting them (Pant et al., 2020) in the curriculum. As a result, it is found some issues of separation, such as mathematics being disconnected from real life, disconnected course from other courses as well as mathematics is divorced from other subjects (Coffland & Xie, 2015), which does not fit the concepts of education of this 21st century regarding solving real-life problems.

Likewise, the predesigned ready-made absolute knowledge is included as content in the mathematics curriculum determined by some experts' teams. Teachers are also forced to strictly follow the structured academic calendar to be able to face their students for examinations. In other words, the mathematics curriculum seems to align with the image curriculum as subject matter[13] (Schubert, 1986). Furthermore, teachers are guided in teaching textbooks mentioned in the curriculum to deliver the contents to achieve the curriculum's predetermined goal. Yet, in such textbooks, a list of problems and some sample solutions are demonstrated, as mentioned in the curriculum, where the authors' efforts seem devoted to earning profit rather than addressing the needs and interests of the students (Sharma, 2016). Such works of authors normally support memorizing the solution to the problems instead of providing the actual contextualized learning environment (Pant et al., 2020). This kind of educating process seems to directly fail in enriching the knowledge of the learners locally, contextually as well as globally.

Moreover, it is found that the contents included in mathematics do not address learners' interests. The nature of contents treats them as the receiver forcefully upgrading a certain level by passing the traditional written examinations of some

[13] It signifies that curriculum is only the subject matter (Schubert, 1986).

hours. As a result, the student's achievement is not as desired in one hand. On the other hand, those who passed different classes also passed just to get a certificate rather than applying for it in their real-life situation. Thus, I have chosen the research topic for the investigation from such contextual dissatisfaction.

Conceptually

From the experience of my learning world of formal education under different levels up to a master's degree as well as being a teacher (educator) at the school level. Even at the university level, I found that educational pedagogy is empowered by teacher-centered culture, which is the concern of behaviorism. In such a learning approach, the observable and measurable changes in the behavior resulting from a chain of stimulus-response connections are studied. From this, it seems that the behaviorist pedagogical approach is a one-dimensional learning approach to understanding human behavior. It does not address the learners' needs, interests, thoughts, and feelings (Moore, 2013). It just accounts for the response of the learners to environmental stimuli.

However, it is taken as a useful learning theory for developing intended behavior in human beings by replacing their unacceptable behavior (Smith, 2013). In the modern learning approaches it is assumed to be too rigid and limited and fails to consider personal agency from the humanistic psychological perspective. In addition, it neglects the mental process of real-life problem solving, and it influences in favor of studying just observable behaviors (Bower, 2008). Therefore, the behavior theory in mathematics classrooms signifies the accumulation of the ideas of teachers in the

learners, treating them as bank accounts[14] (Luitel & Taylor, 2005) using the chain of stimulus-response empowering rote learning, i.e., the priority is given in memorization of the mathematical concepts by means of frequent practice rather than meaningful understanding in the participation of learners while applying this learning theory in the mathematics classroom.

Furthermore, it was not easy to obtain an interactive, collaborative, and cooperative learning environment while reviewing the learning scenario of my learning journey. Similarly, the unconscious mind's thoughts, feelings, and desires that guide learners' actions were cast in shadow while learning mathematical concepts. This type of learning culture is still in existence in our surroundings by making learners compulsory to store the concepts in their minds and demonstrate certain fixed procedural steps of understanding contents (Pant et al., 2020). Thus, instead of a student-centered engaged learning approach, our classroom practices seem to be more lecture-oriented. Teachers dominated students by keeping many students in the same classroom and treating them as passive listeners. As a result, students are compelled to memorize mathematical problems rather than gain a broad understanding of the concepts on the one hand. On the other hand, teachers impose conventional and irritating types of mathematics learning without considering other creative contexts of mathematics learning (Dhakal & Sharma, 2016). In terms of real-world problem-solving, I realized that such a learning culture does not support academic excellence in the twenty-first century.

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[14] As like the depositing money in bank account, teachers deposit the knowledge in the head of students according to behaviourist pedagogy (Luitel & Taylor, 2005).

Likewise, I feel that our teachers are transmitting the absolute knowledge of mathematics (Pant, 2017), which creates a gap between the demand and production in the education sector. Moreover, such *one-way traffic* teacher-cantered instructions seem unfit to create the appropriate learning context empowering active participation of the learners (Freire, 1970). Thus, by incorporating the experiences of the learner and teacher educator, I have chosen this research topic for conceptual change regarding the pedagogical shift from rote learning to engaged learning.

Empirically

In this section, mainly I have unpacked the major ideas of different authors based on the review of some related, and supportive published and unpublished pieces of literature such as books, dissertations of different levels, journal articles, research reports and conference papers due to the efforts of many authors regarding project-based learning particularly STEAM projects empowering engaged learning in mathematics are included. In our context, a limited number of supportive literature related to STEAM education and its application for empowering engaged learning of mathematics are available. Even in such literature, STEAM-based education seems partially addressed. I have shared the efforts of some authors related to STEAM education, mainly focusing on their inquiry area, purposes of their inquiry, its design, participants, and final themes generated from their inquiry to strengthen my research agenda. Moreover, I have studied such literature, which enhances, supports and boosts my study for its success.

Belbase (2006) conducted research for his MPhil thesis and demonstrated the pedagogical context in mathematics classrooms that he felt from the beginning of formal education to the master's level. He also discussed how he determines the pedagogical approaches that influence his practices. He went on to investigate a

message to others about the pedagogical shift from a novice teacher to a postmodern educator and researcher. He used autoethnography to express his feelings about different contexts, such as mathematics learners, teachers, educators and researchers. The data of the study was an ethnographic presentation through his narratives as poems, dramas, dialogues, and stories.

According to Belbase (2006), providing practically any idea to the people, such as measuring their land, dividing the property and available resources, predicting the seeds, keeping records of cultural and social aspects, etc., are not addressed in the existing curriculum and textbooks. Besides, he did not find a connection to mathematics in daily life. But, while he learned mathematical concepts in group work through cooperative learning, he was inspired by this method. Thus, he found that this method of learning mathematics is effective in learners in two ways: one is to share their feelings of difficulties and problems with peers, and then obviously, they learn to develop their reasoning ability by co-working. He believed that a strong concept could be constructed by means of peer-dialogue. Finally, as the findings of his inquiry, he found a change in his belief, reality and pedagogy.

Dhakal and Sharma (2016) have conducted an experimental case study on "Virtual Learning Environment (VLE) in Mathematics Education" to examine whether VLE promotes an engaged learning environment in mathematics classrooms or not. The study was conducted by taking students' enrollment in learning as the key factor. They believed that ICT-based learning was supportive of VLE. The study included 36 students from the Master's second semester in Education (Mathematics) batch 2072/2073 who were teaching Projective Geometry. An experimental group used ICT-based teaching pedagogy. In addition to the observation, interview, and focus group discussion, the academic performance and behavioral changes were

assessed using a baseline and end-line survey. They found a positive impact of VLE in learning mathematics as the students were interestingly involved in group discussion and learning. Also, the academic performance was significantly different based on the test between the two groups of students who were treated separately by conventional and dual modes of learning mathematics. They concluded that there was a shift in conventional pedagogy in university-level education that treats students equally as 'one size fits all.' In their view, it is essential to connect ICTs tools in educating the students of higher-level mathematics, including the concepts in the courses at the time of its design based on the learning theories guided by constructivism and connectivism.

Taylor (2016) wrote a conference paper on the *topic* "Why is a STEAM Curriculum Perspective Crucial to the 21st Century?" It was a literature-based article in which the author clarified that the integration of the arts with science, technology, engineering and mathematics is most for preparing the skillful human resources who can solve 21st-century global issues rather than preparing just another curriculum. After reviewing literature and his own research work in STEAM education, Taylor presented some major ideas, such as STEAM-based education provides sufficient ideas to the teachers to develop a contextual and integrated curriculum with the humanistic vision of education that fits this new era by playing a professional role. Besides, STEAM educators are inspired to design the vision of project based-learning in the journey of transformation through STEAM education.

There was a literature-based article by Remijan (2017) on the topic "Project-based learning and design-focused projects to motivate secondary mathematics students" to create awareness about how teachers can help students develop the ideas of design thinking related to project-based learning and to encourage them. The

researcher himself has developed and implemented various design-focused projects over five years. He has reflected through the series of 12 steps for the engineering design process based on his lived experience as a secondary mathematics teacher, which can guide teachers in developing design-focused projects. In the article, he has provided his insights on the perks of design-focused projects to enhance students' motivation within the mathematics classroom. While carrying out the project-based learning, he frequently observed and reviewed students' activities regarding what they designed, explored and learned. Finally, he concluded that project-based learning and design-focused activities assisted the students in learning mathematics and empowered their engagement.

Pokhrel's (2018) study shares the experiences of implementing Activity Based Mathematics Instruction (ABMI) with reference to 21st-century learning. The study was guided by the learning theories based on 'learning by doing.' In the study, creativity, problem-solving skills, technological understanding, flexibility, critical thinking, communication, collaboration, leadership skills etc., were taken as the skills of the 21st century. Such skills are seem to be addressed in the curriculum. For the purpose of the study, a school in Kathmandu Valley was selected. The students of classes one to ten were involved in designing different activities, including different games, practical activities, math lab activities, exhibitions and projects- designed with the access of subject teachers. The study was conducted under an interpretive research paradigm empowering qualitative research design. Data from the study was collected by frequent observation of the teaching and learning process. Besides, an interview of one/two students from each class was taken.

The study's conclusion was based on the data analysis from the observations and reflections of the students, teachers and the researcher. It was that activities-based

mathematics learning was fruitful in learning and was found helpful in the development of the learners from various perspectives such as teamwork, leading groups, communication, presentation, creativity, collaboration etc. of students. Also, there was a full engagement of the learners in mathematics learning through activities-based pedagogy.

Psycharis (2018) articulated an article under the topic "STEAM in Education: A Literature Review on the Role of Computational Thinking, Engineering Epistemology and Computational Science. Computational STEAM Pedagogy (CSP)" based on the study of different works of the many authors related to the topic. The main purpose of the study through literature review was to outline the inquiry from the various forms of STEAM integration and to highlight how Computational Thinking, Engineering Education Epistemology, Computational Science Education and Arts can be used in this integration and to determine the epistemology supporting the overall process. Moreover, the study was intended to summarize the current status of STEAM education regarding teaching/learning.

The study found that STEAM pedagogy is the appropriate method of teaching and learning and empowering students' creativity and thinking regarding its implementation in the form of a didactic scenario. Moreover, it was concluded that the STEAM pedagogy assists students in developing an inquiry-based learning environment, collecting and analyzing data, and using the concept to solve real-life problems. Besides, they can be engaged through this pedagogy in the abstraction process and physical computational skills and can design and make artifacts based on the engineering concept.

Thompson et al. (2018) also conducted research based on the topic "STEAM (Science, Technology, Engineering, Art, and Mathematics) Education and Teachers'

Pedagogical Discontentment Levels". The purpose of their study was to explore the effectiveness of STEAM pedagogy in the professional development of K-12 teachers.

A pre-post quantitative research design in a one-group of 93 teachers was used as the research design. Moreover, 93 participants from 30 schools within the district were selected as STEAM teachers. For the purpose of data collection, they used three specific types of measures: a quantitative pre-post assessment, classroom observation and teachers' perceptions of STEAM coaching. The data thus obtained were analyzed, and it was found that with the implementation of STEAM education, the teachers' pedagogical discontentment levels were decreasing.

Belbase (2019) prepared a literature-based research paper on the topic "STEAM Education Initiatives in Nepal" to highlight the status of STEAM education in Nepal. The research was guided by the question, "What is the status of STEAM education in Nepal" (p. 1). He analyzed the documents from different means, such as websites, brochures, reports, and government publications related to STEAM education, in order to determine the condition of STEAM education in our context. While analyzing the documents, he focused mainly on STEAM perspectives determining various criteria such as integrated education, STEAM projects, STEAM-challenge and so on.

His study He did not study STEAM education in Nepal despite these initiatives. Moreover, he discovered from his study that the awareness of STEAM education is most for its effective implementation, and there is no formal government initiative to promote STEAM in our context, although the NCF (2007) has initiated integrated pedagogy from classes one to three has started integrated curriculum in school education.

Through the literature-based research article under the topic “Project Based Learning in Mathematics Context,” Serin (2019) intended to explore the main criteria of PBL and its influences on students’ mathematics learning outcomes. The researcher studied in detail the concept of project-based learning (PBL) with the help of the efforts of many authors from different perspectives, such as its criteria, main goals, eight features of PBL, PBL in mathematics and so on. In the process of reviewing the literature, he explored the concepts of PBL with the attachment of learning to practical life. The study concluded that to enable students to construct knowledge in their social context, the application of PBL becomes supportive. Moreover, the concept of PBL is taken as the best method of learning mathematics in the 21st century since the learners get the chance to investigate their own problems in their own efforts, empowering their engagement and creating more opportunities for fostering their abilities of self-critical thinking, smoothly problem-solving and independently working.

Pant, Luitel and Shrestha (2020) have conducted participatory action research under the topic “Incorporating STEAM Pedagogy in Teaching Mathematics” for the purpose of exploring the innovative pedagogy contributing to the empowerment of the achievement of teachers as well as students. With the study, they collaborated with school leaders and mathematics teachers to develop and implement STEAM projects in mathematics teaching per the needs. To complete the inquiry, they worked collaboratively with school leaders and mathematics teachers by taking two schools in Kavre district as their study participants.

They conducted a workshop according to the purpose of the study by dividing it into three cycles, taking one month for each cycle. In the first cycle, teachers reflected on their practices, and they were helped to develop inquiry-based tasks for

mathematics. In the second cycle, STEAM projects were prepared collaboratively and implemented in mathematics teaching. In the third cycle, projects were updated by getting feedback and reflection from the previous two cycles. From the study, it was derived that teachers could develop and use the projects in classroom activities. Students were excited and motivated towards mathematics learning by means of STEAM pedagogy. The achievement evaluation was made by applying rubrics made by school teachers. This signified a progressive change in the achievement of the students. In conclusion, it was drawn that incorporating innovative STEAM pedagogy is essential in mathematics classrooms for meaningful educational practice.

Similarly, Spyropoulou, Wallace, Vassilakis and Poulopoulos (2020) prepared a literature-based research article on “Examining the use of STEAM Education in Preschool Education” to better understand the STEAM pedagogy through the study of related literature in depth. They analyzed the documents unpacked in the various literature by dividing it into different sections: Art integration in STEM, Collaboration and Capacity Building in Schools, Components of a Productive Pedagogy in STEAM, Curriculum Models and the Transdisciplinary Approach, Assessment in STEAM, Rationale for an Integrative Curriculum and Next Generation Science Standards (NGSS). From such study and analysis of the documents, they discovered that the integration of STEAM education within the curriculum positively affects students' academic performance. Moreover, they concluded that to enable the students to generalize the concepts and ideas generated from one context to another, they should be guided by integrated education such as STEAM rather than providing the concepts of isolated disciplines.

Also, Hsiao and Su (2021) conducted research under the topic “A Study on the Impact of STEAM Education for Sustainable Development Courses and Its Effects on

Student Motivation and Learning," intending to accumulate the idea of sustainability into a virtual reality (VR) system to the students by creating the environment of integrated interdisciplinary STEAM education. Besides, the study intended to explore further the relationship between self-efficacy and experiential learning, promoting learners' motivation, satisfaction and effectiveness. For the fulfillment of the research purpose, related literature was reviewed, and the research hypotheses were proposed. The study developed an experiential learning environment with the vision of STEAM pedagogy and education for sustainable development (ESD) using digital content and VR devices. Moreover, a problem-oriented approach was used to guide learners in solving problems.

They used empirical methods as the research method, and questionnaires containing 47 items were developed using Likert's five-point scale as the research tool to examine the effectiveness of the pre-determined programs towards satisfaction, self-efficacy, and learning outcomes of the students. Furthermore, two experts evaluated the questionnaire to increase its effectiveness. Moreover, the questionnaire was analyzed using SPSS 22.0 statistical software to ensure reliability and validity. From their study, it was finalized that the integration of STEAM education and VR-aided course improve learning outcomes and enrich the student's learning.

Likewise, Pant, Luitel and Pant (2020) prepared literature-based articles on the topic "STEAM Pedagogy as an Approach for Teacher Professional Development" to explore the necessities of STEAM pedagogy for TPD. This was prepared by the deep study of the relevant and useful literature from the authors' side with their conclusion that the TPD integrated knowledge of multiple disciplines is required to update and enable teachers to solve the practical problems that appear in their daily lives.

From the study of overall aspects regarding TPD focusing on the sub-topics: TPD in Nepal: Policies and Practices, STEM: A Workforce Development Paradigm, Technology in STEAM Education, An Integration of Arts in STEM Disciplines and STEAM approach for TPD, they concluded that for TPD the implementation of STEAM projects by integrating of STEAM disciplines and designing STEAM projects is immediate requirements. In addition, they summarized that the STEAM pedagogy enriches the knowledge and understanding of both types of teachers: pre-service and in-service.

Formally, the STEAM program was launched by Kathmandu University School of Education(KUSOED) at MPhil level in February 2019 to encourage learners to identify research issues in an integrated way, especially in math, science, technology, engineering, and the arts. The program's main focus was to empower knowledge, skills, and attitudes for developing STEAM-based research design with an understanding of local, regional, and international problems (KUSOED, 2019). The completion of a master's degree in any one discipline of STEM was the entry requirement for the program (KUSOED, 2019). Hence, KUSOED has initiated and created a clear vision for developing STEAM curriculum, pedagogy and potential research for promoting concepts of integrated, interdisciplinary and multi-disciplinary STEAM education in collaboration with other colleges and departments.

I appreciate the contributions made to promoting engaged classroom learning by the different authors and intuitions. However, despite the fact that some efforts are made towards an integrated curriculum, even in the empowerment of ICT, the comprehensive norms of STEAM are yet to be achieved in practice systematically by the government of Nepal. In addition, most of the literature were argumentive and ideas of many authors rather than prepared through real-life application of the

projects. Also, many of them were prepared by the authors based on the education system of their own country according to their own context. Therefore, it is a bit difficult to generalize in our context. Nonetheless, there is a lack of a sufficient number of precise studies about the use of STEAM projects in teaching mathematics for engaged learning in the context of Nepal.

To sum up, the research fostered students' engagement to a certain extent, but if we try to teach mathematics by linking it with the comprehensive and co-dependent disciplines of STEAM, the results may be even better. To promote engagement in learning mathematics through the application of STEAM projects, I have chosen "Envisioning Engaged Mathematics Pedagogy through Project-Based Learning for Nepali Schools: An Autoethnographic Action Inquiry" as my research topic.

Purpose of the Study

The study's main purpose is to explore how an engaged mathematics pedagogy through project-based learning can be envisioned for Nepali schools. Moreover, this study aims to shift pedagogical practices through STEAM projects in teaching and learning mathematics based on my lived experience as a learner and teacher practitioner.

Research Questions

The issues to date do not seem to have addressed the disciplines of STEAM comprehensively. In this concern, an overall approach is to be set forth in order to obtain a viable result relevant to the autoethnographic action research. Thus, I have formulated the following research question to lead this study:

How have I envisioned engaged mathematics pedagogy through project-based learning for Nepali schools?

Significance of the Study

As per the purpose of the study, it explores how STEAM-based mathematics education can be envisioned. Further, this study provides the idea of constructing different projects related to STEAM disciplines to make mathematics classes more creative and more engaging. In addition, I have explored my experiences and thoughts through critical self-reflection by means of this research regarding the mathematics learner and teacher educator as well. Therefore, it is helpful to me to shift my pedagogical practices.

Furthermore, the researcher's interest in this study is to initiate an interdisciplinary and multidisciplinary integrated approach to teaching/learning mathematics especially based on STEAM disciplines (including one or more); such ideas can apply to the practitioners of this field. As the pedagogical practices in Nepalese classrooms seem teacher-dominated, where students are treated as passive listeners, this study will support the implementation of engaged learning approaches. `

Likewise, it is very useful for the stakeholders such as local non-governmental and national or international governmental organizations (I/NGOs) for preparing plans and execution of the projects, and policymakers for preparing and revising existing education policies as well. Furthermore, local government, the provincial government and other educational agencies also can be benefited from it in making different educational programs, educational plans, STEAM outreach programs and educational policies. In addition, I opine that it can be a guideline for academicians to conduct more research on the interdisciplinary, multidisciplinary and engaged teaching/learning approaches.

Limitations of the Study

In this sub-section, I have explored the limitations of my study. I have taken only one sample school of Kathmandu valley with 30 students of grade-IX for completing my inquiry. I have designed the STEAM-based project covering the concept of perimeter and area of plane shapes in mathematics under only one chapter by connecting STEAM disciplines with limited ideas and implementing it in classroom practices. Moreover, I implemented it in the virtual classroom due to COVID-19 using a limited source of technology, i.e., GeoGebra mainly; however, there are many others resources such as math labs and different software boosting mathematics. In addition, it is conducted by taking autoethnographic action inquiry as the research methodology based on the critical reflection on the learning experiences of the researcher. Therefore, the conclusion varies according to contexts and experiences.

Chapter Summary

I explored my lived experience incorporating the learning scenarios of different levels from the beginning of formal education to the university level and even the MPhil level. With the inclusion of the learning environment, I got during my learning journey, I mentioned the birthing of the research topic, i.e., I explored how the research topic was born. Likewise, focusing on conceptual, contextual and empirical aspects, I stated the problem of my research in the chapter in depth. The main cause of generating research topics is reflected in the chapter through the research purpose. Moreover, to complete the research work systematically and determine the dissertation chapters, some research questions are included. The major concerns to whom the conclusion derived from the study can be useful is included in

this chapter as the significance of the study. As a whole, the chapter included the preliminary foundations of the dissertation.

CHAPTER II

PROBING IN MY RESEARCH AGENDA

Chapter Overview

In this chapter, I have explored how I arrived at generating subsidiary research questions to complete my inquiry through my own narratives. Also, I have mentioned some facts related to project-based learning, STEAM pedagogy and its present situation in our context based on my in-depth study of some scholarly articles, books, conference papers, dissertations, and other sources relevant to my research to provide a foundation of knowledge to the readers on the topic as well.

In addition, through this chapter, I have unpacked the concepts of guiding theories to my research with how these theories become helpful in completing my research as well. Likewise, I have wrapped up the chapter by listing all possible subsidiary research questions under the chapter summary.

A Way towards Project-Based Learning

It can be any day in 2020; I am a student at the MPhil level and in a university library with my friends (Syam, Krishna, Gopal and Rajan). Nowadays, we are very happy to learn because of getting interaction and idea-sharing learning environment. For each topic, we discuss ourselves with our teachers. Our teachers are our facilitators. They guide and assist in the proper direction. We discuss, share, and critically reflect on our idea regarding our learning. Therefore, we are happy and do not feel any burden in learning. We are creating new ideas in our learning in interaction, collaboration and critical reflection.

Before routine time, we generally use the library to combine discussion regarding our study with reference to the available literature such that this kind of discussion strengthens our argument. We were also creating new ideas based on it.

It could be a Monday of February 2020; our first period was off due to the urgent work of our teacher. Therefore, we decided to utilize it for special work in that we have to share our learning experience based on our learning from the beginning of formal education to till date. I am here to share my lived experience of learning mathematics in my turn.

I am serious and in a difficult mood while remembering these learning days. Indeed, I examine what I learned in my seventeen years of academic journey as a student: that I am perfect in mathematical formulae, habituated in certain algorithms, and learning methods are unquestionable for me. Moreover, I have learned to follow the suggestions and guidance of my teachers without raising any questions because we have to respect teachers. I have trusted them because I felt they are my pathfinders, and they build up my future. At this moment, I keep on asking myself: Is it true how I treated my teachers? How can I make it easy to learn mathematics myself? Can we change such disengaged pedagogy in learning mathematics?

Figure 1
Reflecting on Learning World

After sharing our experiences, on the way to the classroom from the library, keep on thinking about myself: I developed within the recent one-year period a view that engaged learning is more enjoyable from my running learning journey. Besides, I have built some ideas for making an engaged learning environment in teaching and

learning mathematics using some tools, such as the application of STEAM projects promoting project-based learning. As a result, I have committed to promoting engaged learning by envisioning project-based learning in my inquiry.

Strengthening My Argument on Project-Based Learning

I joined the MPhil level in 2019 with the deeply seated concept of mathematics learning. It is a big challenge to fully engage the students in classroom activities with a superficial understanding of isolated disciplinary concepts (Guo et al., 2020). I used to think that students should be able to solve problems from textbooks instead of developing professional skills or transferable skills on the one hand. On the other hand, I was boosted and encouraged by the University to learn to solve daily life problems rather than only solving the problem of the textbook. I felt a kind of gap between what students learn at educational intuitions (school, college, university etc.) and what they need in the workplace (Guo et al., 2020). During the learning journey, I consulted with the many ideas shared by different authors and intuitions regarding it under the facilitation of the University and professors as well.

I have set my research agenda to transform pedagogical practices based on my interest in learning at the MPhil level. Next, I found project-based learning (PBL) as the best way to shift such educational practices by providing learners an opportunity to solve real-world problems and knowledge construction procedures. Besides, I felt that PBL is an inquiry-based learning technique that engages learners in constructing knowledge, enabling them to design and work with the meaning (Krajcik & Shin, 2014). I searched the historical perspective of PBL and found that John Dewey, one of the early proponents of PBL, unpacked the idea of such education by developing a theory of learning by doing (Bender, 2012). Likewise, Greeno (2006) connected project-based learning with Jean Piaget's situated learning perspective. So, I agreed by

means of my inquiry that such an instructional method plays a vital role in empowering engaged mathematics learning.

Moreover, I was inspired by the PBL due to its support in driving questions, focusing on the goals, involvement in activities, collaboration in learning, using scaffolding technologies and encouraging the creation of tangible artifacts (Krajcik & Shin, 2014). Furthermore, PBL promotes the efficiency of integrating knowledge and action since by applying PBL in mathematics classrooms, students learn mathematical concepts and use it to solve the problems they have faced and draw meaningful results (Thomas, 2010). Thus, I concluded that it supports producing highly qualified and collaborative products from overall perspectives.

In addition, with the learning journey, I found that a mathematics learning project can be useful for students if it becomes meaningful and applicable to fulfilling some academic willing (Bender, 2012). Since PBL creates a strong potential foundation for learning through engaging them (Serin, 2019), I agree that PBL becomes more effective and appropriate in learning mathematics.

In the sense of strengthening the argument of my inquiry, I have studied five goals of PBL mentioned by Loyens, Magda, and Rikers (2008) as “to construct an extensive and flexible knowledge base, to become effective collaborators, to develop effective problem-solving skills, to become intrinsically motivated to learn and to develop self-directed learning skills” (p. 413). It supported me in driving my inquiry using PBL empowering learners for collaborative learning and encouraging them to search for solutions to real-world problems. Thus, I was encouraged by the concepts of PBL and the shared ideas of various authors and even my professors to complete my inquiry. Arriving at this stage of my inquiry in promoting project-based engaged

learning, I came up with the following subsidiary research question: *how have I connected with disengaged mathematics learning?*

My Connection with STEAM Pedagogy and STEAM Projects

As I confirmed PBL as the means of promoting engaged mathematics learning, I was inspired by interdisciplinary and multi-disciplinary project-based learning. In particular, I consider STEAM-based projects as a pedagogical approach to completing my inquiry. From my learning journey at the MPhil level, I was excited about it as I noticed that preparing human resources with 21st-century skills requires the integrated knowledge of multiple disciplines (Pant et al., 2020). Moreover, they need content knowledge and skills of creativeness and innovativeness, critical thinking, problem-solving, and decision-making, which are regarded as twenty-first century skills through education. For such a development of the learners, the core knowledge of separate disciplines is incomplete and insufficient. To solve such a type of separation problem and interlink the disciplinary concepts, I found that many countries, as the recent pedagogical shift in the education system, highly practice STEAM-based learning.

As the nature of knowledge created by means of STEAM pedagogy, students construct knowledge and use it in solving the problem and strengthen the concepts through an interdisciplinary approach to be increasingly set forth. Also, students are assisted in solving the issues in day-to-day life by integrating concepts from science, mathematics, engineering, arts and mathematics (Pant et al., 2020) in STEAM pedagogy. Therefore, in the education system of many countries of the world, employing STEAM pedagogy is taken as the major source of inspiring students to develop critical and imaginative thinking with entertainment to face 21st-century challenges (Pressick-Kilborn et al., 2021). Likewise, I found that STEAM education

as the arts supports observing, understanding, thinking, creating and learning STEM disciplines in new ways. Besides, I was inspired by connecting the discipline of Arts to STEM since it makes learning STEM disciplines critical and creative. Next, combining Arts in STEM empowers a richer learning experience for an individual rather than STEM only. Land (2013) stated that the arts make able to "re-invigorate the educational platform, providing not only an interesting approach but also opportunities for self-expression and personal connections" (p. 548). Thus, I ensured that implementing STEAM pedagogy in mathematics classrooms creates a fully engaged learning environment.

Furthermore, with the learning journey of MPhil level, I envisaged STEAM pedagogy in mathematics classrooms since it is applicable to provide students with an active participatory learning environment. It includes the tasks related to the context of their real-life, ill-defined problems, various techniques of addressing a problem, integration of many disciplinary concepts and strength of the disciplinary knowledge in a multidisciplinary perspective. Therefore, I am convinced that the projects incorporating STEAM disciplines help in developing learners from overall perspectives. Besides, I am interested in STEAM education because of its popularity in managing creative and artistic learning environments for the STEM disciplines (Henriksen, 2011), where the key concept of STEAM is interdisciplinary and multidisciplinary integration. Thus, it seems that the concept of STEAM education is accepted as a means to minimize the disciplinary boundaries existing in conventional educational practices by connecting the disciplines of science, technology, engineering, arts and mathematics (Yakman, 2008). In addition, STEAM education empowers the students to think broadly, express their ideas in innovative and creative ways, feel pleasure in learning, take ownership over their learning, work

collaboratively with others, and finally, understand the ways that science, mathematics, engineering, arts, and technology work together in addressing real-life issues.

On the one hand, connecting art with STEM disciplines enables students to solve complex problems by implementing their analytical and creative minds together (Singh, 2021). On the other hand, STEAM pedagogy also supports teachers in their professional development. Moreover, Taylor (2016) advocated that the STEAM instructional approach is a key factor in the professional development of teachers that influences their pedagogical discontentment levels. Further, in STEAM education, "a variety of pedagogical techniques for promoting participatory learning and higher-order thinking skills" (p. 91) in students are used. As a result, it boosts decreasing teachers' pedagogical discontentment levels. Furthermore, regarding the strengths of STEAM education influencing the development of teachers' pedagogical contentment levels positively, Taylor (2016) added that

> *STEAM education involves teachers in developing a humanistic vision of 21st-century education and their role as professionals; STEAM education provides a creative design space for teachers in different learning areas to collaborate in developing integrated curricula; STEAM education engages students in transformative learning, which is based on five interconnected ways of knowing: cultural self-knowing, relational knowing, critical knowing, visionary and ethical knowing, and knowing in action.* (p. 92)

From the various positive aspects of STEAM education according to the modern issues appearing in education, it is taken as the appropriate and effective pedagogy in educating process according to a recent scenario (Kuenzi, 2008). By avoiding the concepts of separate disciplines, STEAM integrates the different

disciplines into an integrated and interrelated form connecting with the context. Such practices inside the classroom produce critical thinkers, problem solvers, and next-generation innovators (Singh, 2021). STEAM education has seen remarkable growth in the fit of human resources of different sectors while evaluating the academic programs and their productions of the many countries implementing such education.

However, STEAM education is becoming an appropriate way of directing learners' inquiry, interaction and critical thoughts (Singh, 2021) through their engagement. The effectiveness of STEAM education depends on the process (planning, implementing, and evaluating/reflecting) of STEAM education (Jho et al., 2016). The process seems meaningful, while each discipline in STEAM education is discussed by means of STEAM-related projects. Such projects help learners understand the content in their own engagement by applying an integrated form of learning that resembles real life. On the other hand, these projects empower the development of crucial skills such as efficient communication, problem-solving, innovation, critical thinking and creativity in the learners.

Lee et al. (2013) argue that applying STEAM projects in mathematics teaching impacts students' motivation and learning; however, the design of the projects for STEAM education is challenging. The projects need to clearly outline the connection between the STEAM disciplines and the existing educational practices (Park & Ko, 2012). Indeed, STEAM projects in mathematics teaching/learning are expected to help promote students' creativity, collaboration and logical thinking to cooperate with them in relating mathematical concepts with other disciplines. Furthermore, an essential part of using STEAM projects to learn mathematics is to develop collaboration between the learners, enabling them to receive and apply constructive feedback and then share the ideas regarding outcomes of problems (Siregar et al.,

2020) derived from their attempts. Therefore, these requirements need to be addressed from engaged learning perspectives during project design.

By using STEAM projects in teaching mathematics, teachers get opportunities to grow interconnected knowledge from their efforts. Indeed, the purpose of using STEAM projects in mathematics is to provide a different flavor to mathematics learning and enrich the concepts (Roth, 1998) to both teachers and students. Besides, the STEAM project makes available a design space for the teachers to design the projects by incorporating various subjects (Taylor, 2018). Thus, it facilitates the teachers in planning and developing favorable learning scenarios for all in their own participation and contribution (Singh, 2021) through the projects. Learners also get the chance to question and develop critical thinking to face the issues from multiple perspectives (Ghanbari, 2015) in such projects. Therefore, I ensured that the STEAM pedagogy promotes a fully student-centered learning environment by integrating the concepts of different disciplines, including Science, Technology, Engineering, Arts and Mathematics, as the demand of 21st-century education.

Likewise, from the idea of Hsiao and Su (2021), STEAM-based pedagogy encourages learners to learn *by doing* through their cooperation and collaboration. Thus, I agree that the STEAM education driven by STEAM projects is brought into practice to empower students' engagement and mmake them able to solve the problems

According to the Ministry of Education (2005) of Singapore, TLLM means to teach with a better understanding of the concept by engaging students to brighten their future instead of accumulating the contents for preparing scheduled tests and examinations, which is the main theme of engagement learning through STEAM projects. Therefore, STEAM project-based mathematics learning supports engaged

learning and prepare the students for addressing the demands of the 21st century. As I arrived here with the essential idea of STEAM-based pedagogy and STEAM projects, I came up with the subsidiary research question: How did I develop the notion of project-based pedagogy for engaged mathematics learning?

Examining the Condition of STEAM Education in Our Context

In our context, STEAM education seems to be yet in the germinating stage. The government has prioritized ICT-based education at the school level through a school reform project in which ICT-assisted and "child-friendly" pedagogical practices are prioritized in all schools (Ministry of Education Nepal, 2007). The modern pedagogical practices gradually have begun in our context with the inclusion of some remarkable efforts in national plans on education, such as the "School Sector Reform Plan 2009–2015" (MOE, 2009) and the "ICT in Education Master Plan 2013–2017" (MOE, 2013) with goals to use ICT to update modern pedagogical practices. From such efforts, it is clear that the priority is given to empowering technology which is one discipline of STEAM education, rather than implementing interdisciplinary and multidisciplinary STEAM education.

Likewise, to bring change in the education system from a worldwide perspective, the concept of integrated education has been initiated by the government of Nepal. In other words, implementing modern education concepts in our context seems to be in process. To continue the efforts regarding it, the national education policy is revised, level-wise curriculum and textbooks of some classes are revised, and even it seems in the process for some classes. Moreover, the National Curriculum Framework (2007) has initiated an integrated curriculum in the first phase from grade one to grade three and the second phase in grades four and five of basic level. The first phase of integrated education is initiated with the objectives: "to give children the

opportunity to be introduced to formal education and basic literacy, mathematical knowledge and life skills and develop the habit of personal health and hygiene" (p.43). In addition, with the application of the curriculum in the education system, it is expected that the students become familiar with their surroundings and get the chance to learn in their mother tongue.

Furthermore, as the implementation of the task of the National Curriculum Framework (2007), integrated education has applied up to grade three from the academic session 2022 (2079 B. S.) in all schools of the country. Although the integrated curriculum is implemented from initial classes of school education, sufficient programs regarding teachers' awareness and professional development (TPD) about integrating the concepts of different disciplines seem to be in shadow. Most of the teachers are confused about this new practice. Due to the lack of well-managed practice, there is a chance of failing the program on the one hand, i.e., whether the word integration according to its meaning and objective; is appropriately applied or not in real classroom practices it is doubtful. On the other hand, there is a tiny effort regarding integrated education by connecting some disciplines and disciplinary skills; however, formally, STEAM education programs, including all disciplines, are not found in such programs in national level education policy.

Moreover, Kathmandu University School of Education (KUSOED) at the MPhil initiated a formal program regarding STEAM education, including nine STEAM learners from February 2019 to empower the graduates to determine the agendas of inquiry, especially in mathematics, science, technology, engineering, and the arts in an integrated way (KUSOED, 2019). Besides, the program was launched by focusing on knowledge, skills, and attitudes to develop a STEAM-based research design such that the problems and issues can be understood from local, regional, and

international as well (KUSOED, 2019). Also, KUSOED has started the formal program in STEAM education under PhD and even at the Master's degree level. The major aim of University through STEAM education seems to develop scholars with the help of scholarly interactions and ideas sharing among them from a holistic perspective, making them aware of theoretical, philosophical, pedagogical and practical knowledge, skills, attitudes, and habits (KUSOED, 2018). This effort made by KUSOED seems to be a milestone in developing the vision of integrated STEAM education in Nepal.

However, such a type of engaged teaching and learning environment is rarely found in classroom practices. Most of the classroom environment is driven by a teacher-dominated learning environment in our context. I have determined the agenda of my inquiry to promote engaged learning in mathematics through the use of STEAM-based projects. Furthermore, I felt the requirement of in-depth supervision from education planning and curriculum revision to human resources management on the one hand. On the other hand, for the program's effectiveness, local, provincial and central governments must be more responsible. As I arrived here with some challenges of applying STEAM pedagogy in our context, I came up with the subsidiary research question: how is my implementation of project-based pedagogy in learning mathematics?

Guiding Theories to My Inquiry

Theories are guidelines for the overall research process. Therefore, without theories, research cannot be imagined; however, which theory is applicable for what type of inquiry is based on the research topic and the nature of the inquiry. Since my inquiry promotes engaged learning through STEAM projects, students are required to be engaged in knowledge construction by interaction, collaboration, and critical

reflection. Next, my interest in this inquiry is to transform my professional practices. Therefore, I concluded that my research is mainly affected by constructivism and transformative learning theory.

Constructivist Learning Theory in My Inquiry

The existing pedagogical approach emphasizes preparing students for the written examination of certain hours and discourages deep learning (Dagar & Yadav, 2016). In our context, however, the modern view of teaching and learning in the worldwide education system is to promote learners' engagement in learning. For the empowerment of engaged learning, in my inquiry, students are required to reflect, search, and use their capacity to take the initiative and be creative (Dagar & Yadav, 2016). They have to construct their knowledge in their effort based on their previous knowledge and develop deep understanding through active engagement. Also, they have to take learning as the actively gained matters rather than obtained from passively listening to teachers' lectures (Woolfolk, 1993). These all are unpacked under the domain of constructivism. Therefore, I have chosen one of the major theories of my inquiry, i.e., constructivism.

I agreed with Jean Piaget's view regarding knowledge construction in my inquiry since he advocated that knowledge is gained from the self-construction that the learners should frequently attempt (Dagar & Yadav, 2016). According to him, learners proceed through the steps of assimilation, accommodation and equilibrium in acquiring the disciplinary concepts.

Likewise, as the research participants have to interact, collaborate and share ideas for learning in my inquiry, I am linked with the father of social constructivism, Vygotsky's view that the learners and mentors share, compare and debate by means of interactions in the sense of constructing knowledge (Vygotsky, 1978). According

to him, knowledge is created in the social and cultural context of the learners. Social constructivism highlights the interaction between teachers and students, and even between students and students, which is essential for constructing knowledge. In the social constructivist approach, the role of the teacher changes from knowledge provider to facilitator and scaffolder (Dagar & Yadav, 2016), which I played in this inquiry. Indeed, I have played a role in this inquiry as a scaffolder by assisting the participants with the learning environment of focusing collaboration among them and sharing ideas that the students individually have.

Moreover, I have supported my participants in every step of my inquiry in the sense of learning mathematics, empowering the participants' engagement by employing students-centric classroom activities that promote collaboration (Dagar & Yadav, 2016), such view about the nature of knowledge is beyond of the behaviorism (Sharma et al., 2017) since the behaviorism theory highlights knowledge is gained through the transmission process. Likewise, I have provided daily assignments to all participants based on the concepts of discussion for their self-regulation and reflection, employing the view of Von-Glasersfeld (1995) using constructivism that learning is not possible by means of the chain of S-R. For actual learning, self-regulation, reflection and abstraction of the learners are essential factors.

Constructivism rejects absolutist epistemology because it is based on the idea that learners can construct disciplinary concepts through active engagement rather than passive presence in the environment (Sharma et al., 2017). It means that

constructivism focuses on "*known is made but not given,*[15]" as I have managed individual responsibility to learn in my inquiry.

According to Kurt (2021), there are some components of constructivism: knowledge is in constructed form, it is personal, learning is happening in the active situation from social activity, it is contextual, it occurs in learners' minds, and the major factor of learning is motivation. Thus, as the constructivist theory empowers the engaged learning environment in teaching and learning and my research is centered on engaged learning, this theory is taken as the theory guiding my work.

Furthermore, Hein (2007) claimed that constructivism refers to the idea that each learner individually and socially constructs knowledge based on their learning. Indeed, knowledge is constructed by a frequent process of being built and tested (Bodner,1986) to find updated knowledge. There is no pre-determined pattern of knowledge construction (Bada, 2015). Instead, learners come with prior knowledge and learn from modifying the previous knowledge based on the existing learning situation (Phillips, 1995). To examine the best effect of educating process, it is essential to think of the parameters such as the encouragement to the learners in logical and critical thinking, in-depth understanding and discouragement of rote learning. For this, constructivism is appropriate because it concerns thinking and understanding about learning disciplinary concepts (Bada, 2015). Since constructivism bases learning on students' questions, efforts, and explorations, they gain ownership of the learning. As a result, it promotes their social and communication skills.

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[15] Knowledge is in the process of construction; it is constructed by teacher in appropriate environment. Teachers can not give knowledge.

Through constructivism, students learn about articulating their ideas as well as collaborating on tasks with the help of sharing in group projects (Bada, 2015) in one hand. On the other hand, they must share their ideas and learn to "negotiate" with others to become successful in the real world. Besides, this learning theory signifies knowledge construction that individuals build new knowledge through interaction based on their prior knowledge, beliefs, ideas, events, and activities. Thus, as my study agenda requires students' active involvement to construct knowledge through engaged learning, constructivism learning theory becomes a guiding theory to complete my research.

Transformative Learning Theory in My Inquiry

My inquiry is to shift pedagogical practices from teacher-centered to student-centered, promoting engaged learning through project-based learning. As I have unpacked, the major agenda of my inquiry is my experience of disengaged and de-contextualized mathematics teaching and learning in the previous chapter (see chapter-I) and in detail later (see chapter-IV) as a learner and teacher both transform in my pedagogical practice. For this, I have taken transformative learning[16](TL) theory as my research's other major guiding theory. Mezirow and Marsick (1978) contributed to the development of the theory at first as a particular type of adult learning theory. From the historical perspective, it seems that the theory was born from the collaborative works of Jack Mezirow, Victoria Marsick, and others (Howie & Bagnall, 2013). However, in the development of the theory formally in the education system, many philosophers and psychologists, such as John Dewey, Parker

[16] In the sense of shifting deeply seated values, beliefs and concepts towards teaching and learning pedagogy from teacher centred to engaged learning the transformative learning (TL) theory is used.

Palmer, Carol Gilligan, Abraham Maslow and many others, who focused on subjectivity and lived experiences contributed.

But it seems that the theory is in application due to the large-scale collaboration between many practitioners through their descriptions and understandings (Mezirow, 1991; Taylor et al., 2012). Moreover, the transformative learning theory articulated by Mezirow relies on the theory, guided by the emancipatory interest of Habermas (1968), including particular types of conversations (discourses) that are free, open and active participatory. Such learning theory is grounded in critical theory and empowers such ways of meaning-making based on a set of unquestioned assumptions that are sought, integrated and acted upon. In the opinion of Mezirow (2000), transformative learning is

> *the process by which we transform our taken-for-granted frames of reference (meaning perspectives, habits of mind, mindsets) to make them more inclusive, discriminating, open, emotionally capable of change, and reflective so that they may generate beliefs and opinions that will prove true or justified to guide action* (p. 7-8).

Indeed, Mezirow's TL theory describes an adult's assumptions, beliefs, and expectations regarding the world (Howie & Bagnall, 2013). As Mezirow terms *disorienting dilemmas, critical reflection,* and *rational discourse* as the elements of the TL, the learning becomes successful from applying one or more of these elements. It is thus taken as a kind of learning approach by means of it adult determines the factors affecting their thinking, feelings, and actions (Hodge, 2014) through their critical self-reflection, i.e., TL signifies a specific vision about adult understanding and learning framework (Dirkx, 1998) regarding it.

Moreover, while assisted by TL, an individual examines his/her beliefs through critical self-reflection and constructs a new meaning. Content reflection, process reflection, and premise reflection (Mezirow, 1991, 2000) are primarily regarded as crucial concerns in the learning process. Besides, in transformative learning, "rational discourse is presented as the form of discussion with other people, focusing on personally and socially held beliefs and assumptions to highlight any incongruencies, biases, or blind spots in those beliefs and assumptions" (Howie & Bagnall, 2013, p. 7) to address them. It follows that TL theory explores in my inquiry how individuals understand existing frames of reference and change their beliefs for multi-age students; however, it is a critical and constructivist theory targeted to adult learning.

Furthermore, TL empowers students in shifting paradigms, enabling them to understand themselves and their relationship with other humans and the natural world (Bourn & Soysal, 2021). Thus, a transformative approach assists me in engaging the students to critically reflect on the assumptions underpinning their values and beliefs (Taylor & Taylor, 2019) in my inquiry. Besides, the philosophy of TL supports my inquiry for developing students' trans-disciplinary abilities in overall development, decision-making and designing STEAM project-based learning in mathematics. Indeed, TL learning includes lifelong, collaborative, problem-based, active and experiential learning, promoting the students' logical thinking and problem-solving (Bourn & Soysal, 2021). As a result, it helps me to create a learning scenario that fosters the development of the learners from a holistic perspective.

In addition, this learning theory empowers students to re-conceptualize and reshape their outer and inner worlds with the help of cognitive, emotional, social and spiritual perspectives (Taylor & Taylor, 2019), which is the focus point of project-

based learning as well in my inquiry. Besides, I am assisted by this theory in enhancing learners' conscious awareness of themselves, others and the worlds they co-construct, critical reflection from their ideological prisons (Taylor, 2015).

As the idea unpacked by Freire and Macedo (1995), there are mainly three instructional approaches that foster emancipatory transformative learning: the first is critical reflection, the second is a liberating approach to teaching, and the third is a horizontal relationship between student-teacher. The combined efforts of such pedagogical concepts encouraged me, and I believed that the learning theory in my research was the central part of helping learners' development and awareness of agency to transform their society and own reality on the one hand. On the other hand, the dialogical methodology and the teachers' role on an equal footing with students fostered me in developing the conceptual framework of my agenda.

Yet, I have highly inspired and concluded to go through this theory in my inquiry due to its multi-dimensional learning processes such as Mezirow (1991) mentioned the ten non-sequential processes of transformative learning as follows:

> *A disorienting dilemma; self-examination with feelings of guilt or shame; a critical assessment of epistemic, sociocultural, or psychic assumptions; recognition that one's discontent and the process of transformation are shared and that others have negotiated a similar change; exploration of options for new roles, relationships, and actions; planning a course of action; acquisition of knowledge and skills for implementing one's plans; provisional trying of new roles; building of competence and self-confidence in new roles and relationships and reintegration into one's life based on conditions dictated by one's new perspective.* (pp. 168-169)

According to Mezirow, a person may go through these ten processes in any order during their learning. Thus, from the above non-sequential learning processes of the TL, it is clear that this learning involves in-depth experiences that empower to shift learners' thoughts, feelings, and actions changing the approach of existing in the world permanently (Morrell & O'Connor, 2002). Thus, I agree that the concepts apply to developing the learning model of any age group; however, it originated for adult learning.

Likewise, as Taylor (2015) argues, five interconnected ways of knowing for TL, including *cultural-self knowing, relational knowing, critical knowing, visionary and ethical knowing* and *knowing in action* (Taylor, 2015)*;* TL seems more effective in achieving academic as well as the holistic performance of the students if it can be applied by means of STEAM project-based pedagogical practices in the mathematics classroom.

Also, the concept of TL becomes more effective in classroom application if learning practices are student-centered, participative, interactive or constructive (Christie et al., 2015). Next, open and voluntary discourse is one of the major requirements of TL since it provides opportunities for the learners to involve in teamwork for a common solution (Schnepfleitner & Ferreira, 2021). Besides, for TL, it is necessary to create opportunities for the learners to critical reflection. Thus, by becoming aware of own knowledge, feelings and desire for change, the learner can experience transformation (Rajbanshi & Luitel, 2020) in the learning process.

The approach of TL to learning is appropriate for both teachers and students because it promotes "collaboration, participation, empowerment, accountability, confidentiality, acknowledgment of obligations to the subject, transparency of goals, methods, and motives, benefits to the subject, and opportunity for subjects to present

themselves in their voice" (Deal, 2006, p. 4). Furthermore, engagement in TL promotes understanding of the spirit or soul that lies at “heart of personal, scholarly, and organizational life and, therefore, of change” (Anglin, 1996, p. 99). So, I believe that the teacher engaged in transformative learning works with the students' questions, facilitates them for questioning and develops a vision of responding to their questions in their involvement, promotes interdisciplinary contexts of learning and fosters observation, hypothesizing, experimentation and discovering for knowledge construction.

Finally, the TL theory empowers me to encourage my research participants to develop the vision of critical and creative thinking and to express their own viewpoints on the different problems/issues in different ways so that they succeed in developing reflective thinking towards problems. It supports being a transformative practitioner, which is the ultimate goal of my research agenda by applying STEAM projects in mathematics classrooms. Therefore, it is obvious that this theory strongly guides my study to achieve the intended objective.

Chapter Summary

I explored the ideas about how the subsidiary research questions are generated in the completion of my inquiry with my narratives as well as with my in-depth study of the ideas and views of many authors that supported me. In addition, I envisaged the vision of two main learning theories: constructivism learning theory and transformative learning theory, that directly guide my study in this chapter. The subsidiary research questions that are generated in this chapter are listed as follows:

1. How have I connected with disengaged mathematics learning?
2. How did I develop the notion of project-based pedagogy for engaged mathematics learning?

3. How is my implementation of project-based pedagogy in learning mathematics?
4. How have I and my students reflected on the outcomes of the project-based pedagogy?

I have created these subsidiary research questions for an auto-ethnographic action inquiry. Therefore, I have dealt with these research questions indirectly in the subsequent chapters (IV, V, VI & VII), where the answers are unpacked in a broader sense rather than in a specific form. Thus, for an in-depth understanding of the answers to the subsequent research questions, readers are required to go through the whole chapters of this dissertation.

CHAPTER III

RESEARCH METHODOLOGY

Chapter Overview

I explored how I have finalized my research topic, how I have generated the research issue, the purpose of my study, guiding research questions, and the significance of the study in chapter-I. Likewise, I unpacked mainly how I have reached in constructing subsidiary research questions in support of principal research questions and about guiding theories of my inquiry in chapter II. In this chapter, I have reached out to mention the research philosophy of my inquiry. I have explored the concept of this overarching term relating to the construction of knowledge and the nature of such knowledge in my study.

Indeed, any inquiry is guided by some underpinning philosophical assumptions that constitute meaningful inquiry and about appropriate research method(s) is/are helpful in theme generation through the study. Therefore, the research philosophy under my study contains some essential assumptions by which I viewed the context of my study, which I have included in this chapter. Such assumptions underpin my research design and the methods that I used in my inquiry. Moreover, I have included the philosophical assumptions, research methodology, data collection tools, its analysis and interpretation, field engagement strategies and meaning-making process, research site and participants, quality standards and ethical consideration of my inquiry in detail in this chapter.

Philosophical Assumptions in My Inquiry

In the research, philosophy represents the source of inquiry, nature of knowledge and construction of knowledge from inquiry (Bajpai, 2011). In simple

terms, it is a belief regarding data collection, analysis and its use. My inquiry represents a set of beliefs and assumptions regarding concept formation.

Moreover, a deep understanding of philosophical assumptions and research paradigms is essential since it creates the foundation for successfully choosing the strategies and methods to complete my inquiry (Greener, 2008). Under the philosophical assumptions, I have included the assumptions about the construction of knowledge (epistemological assumptions), the realities that I encountered in my research (ontological assumptions) and the extent and ways that my values influence the process of my inquiry (axiological assumptions). As my research is a qualitative autoethnographic action inquiry, it mandates multiple realities based on the diverse experience and understanding of participants from different cultures and communities. Thus, I have prioritized the discussion of philosophical assumptions in this section.

Ontology

Ontology refers to the nature of existence (Crotty, 1998) in research as social entities (Bryman, 2012) or reality (Hammersley, 1992) for the inquiry. It is called the theory of reality (Khatri, 2020) in research philosophy. Lincoln and Guba (2013) mention ontological knowledge to be explored with the questions like, “What is there that can be known?” or “What is the nature of reality?”; (p. 39). However, the different perceptions of the reality of my inquiry are reflected by the different positions of ontological assumptions.

Furthermore, as my research is qualitative with the interpretive paradigm, the ontological perspective of my research implies multiple realities (relativism). In my research, the reality is formulated from students' perceptions, efforts and actions. As the interpretive researcher, while talking about ontology in my inquiry, mathematics

can be learned, and reality can be constructed meaningfully in multiple ways using the STEAM project-based learning approach to promote learners' engagement. As the participants of my research are from various communities and cultures, I believe that they have various understandings, levels of knowledge and experience. They convey multiple realities, and such realities can be explored and established using the interactions among research participants and between investigators and the subjects of inquiry (Chalmers et al., 2005), reflecting the ontological assumption of my inquiry.

In addition, I have linked with the argument of Lincoln and Guba (1985) that the realities rely on other systems for appropriate meanings since reality is contextual and subjective. Besides, as a critical paradigm also guides my study, my assumption about ontology is based on an ontology of historical realism, as it relates to oppression (Kivunja & Kuyini, 2017) and the virtual reality determined by social, cultural, political and economic, ethnic, gender and religious factors existing in the context (Denzin & Lincoln, 2018). These factors interact with each other to create a social system of reality (Rehman & Alharthi, 2016). Therefore, the reality and thoughts in my study are mediated by these perspectives.

Likewise, my assumption under post-modernism is reality is a human creation. It empowered me to treat reality as a socially constructed form rather than accepting its objective existence in the external environment. Moreover, it inspired me to reject the views of reality, such as fixed ideas and universal and eternal foundations that can be copied. Besides this, my interest as a postmodernist practitioner is neither to establish my knowledge realm nor to discover the absolute truth or reality. My interest is here to pursue approximate truths or realities, including contextual knowledge according to the time as Guba (1990) argued that reality is constructed only approximated, but it cannot be achieved completely. In other words, as Denzin

and Lincoln (2018) argue that “there is no single truth- that all truths are but partial truths” (p. 250); my research participants constructed their own reality instead of having perfect perceptions of absolute truths, due to which reality is not the same for every student in my research study.

Epistemology

Epistemology refers to the nature of knowledge that represents acceptable, valid and legitimate knowledge and the way of sharing ideas with others (Burrell & Morgan, 1979). Indeed, epistemology deals with the complete sufficient and valid types of knowledge in my inquiry (Gray, 2014). Besides, Burrell and Morgan (2005) clarified that the epistemological assumptions signify some sort of idea and their truth or false. Moreover, it demonstrates the nature and sources of such knowledge that the researcher uncovers in their social context from the investigation. In addition, it assists in providing research guidelines to the researchers to determine the scope of the entire study (Khatri, 2020).

Likewise, Guba and Lincoln (1994) explored the concept of epistemology by asking, “what is the nature of the relationship between the knower or would-be knower and what can be known” (p. 108). Thus, as I have chosen one of my research paradigms, interpretivism, my epistemological assumption is interactive/discursive and inter-subjective knowledge, where the assumption about subjectivist epistemology signifies the meaning generated from the data obtained from the investigator’s own thinking as well as got from the interactions with the participants and then the processing of the data from a cognitive perspective (Kivunja & Kuyini, 2017). Moreover, the knowledge in my research is constructed in the social processes by the participants instead of determining it objectively (Carson et al., 2001). Thus, the epistemological dimension of my research was that the knowledge is in contextual

and constructed form. As my research was intended to explore how engaged mathematics pedagogy through project-based learning can be envisioned for Nepali schools, the disciplinary content knowledge was created in the active involvement of the learners through their attempts under the teacher's supervision.

The critical paradigm assumes transactional and subjective epistemology, in which the researcher interacts with the participants; in my research, the knowledge is created based on the participants' lived experiences and their learning world and context. It inculcates similar experiences to the researcher (Kivunja & Kuyini, 2017) rather than the *give-and-take* procedure. Also, as a critical educational researcher in my inquiry, I have tried to be self-conscious of the participants' own epistemological presuppositions. I have communicated in the inquiry process clearly with the participants so that no one is confused concerning the epistemological and political baggage they bring to the research site (Kincheloe & McLaren, 2005). Thus, in my inquiry, participants were more active through dialogue in the learning process as critical theory demands a more transactional and subjectivist epistemology where "the investigator and the investigated object were assumed to be interactively linked, with the values of the investigator . . . inevitably influencing the inquiry" (Guba & Lincoln, 1994, p. 110). Therefore, based on the epistemological view, participants individually in my research study were more actively involved in the discourse community regarding mathematics learning using the STEAM project-based approach.

Likewise, postmodernism encourages a pluralistic epistemology utilizing multiple ways of knowing. Knowledge is fundamentally fragmented and unstable according to this perspective. Besides, the possibility of having objective knowledge is unaccepted by this paradigm. Moreover, as a postmodernist researcher, my study is highly inspired by the principle of constructing knowledge socially in the regular

efforts of and reflectivity of the participants instead of gaining it as the objective and universal form (Freedman & Combs, 1996). Therefore, I claimed that we acknowledge the existence of knowledge in the socio-cultural, local and contextual environment rather than prioritizing the long-term existence of universal, objective and complete knowledge (Freedman & Combs, 1996) through this inquiry as accepted in the postmodern research paradigm. In addition, the content knowledge regarding mathematics was created by participants through the means of engagement, interaction and reflection using STEAM-based projects in multiple ways.

Axiology

It demonstrates the study of values and ethics during my inquiry. Also, it incorporates questions about how I have dealt with my value and my research participants. Also, it explores the definition, evaluation and understanding of the appropriate and inappropriate concepts regarding the inquiry (Khatri, 2020). Moreover, it reflects the value of researchers' techniques of treating the different aspects of their study, the participants, the information and the audience who are supposed to know the research result. It prompts the values guided by the research and determines the values or outcomes emerging from the research. Like the idea of Heron (1996) that the investigators explore their axiological skill with the articulation of their values by examining their inquiry of conduction and its process, I have demonstrated my value in my inquiry.

Since axiology signifies the judgments regarding the value (Saunders et al., 2012), it helped me connect the research purpose, research question, research method, participants, research tools, etc. In the interpretive research paradigm, a *balanced axiology* interprets that the inquiry's findings reflect the investigator's values (Kivunja & Kuyini, 2017). As a researcher, my role in interpreting text and collecting and

analyzing information was all value-laden. Also, as an interpretive researcher, I study the social reality of the participants from themselves by exploring the insider perspective in my inquiry. Here, the experiences and values of my participants (students) and researcher (myself) influenced the data gathering and its interpretation.

Likewise, the critical research paradigm focuses on the *axiology* of respecting cultural norms (Kivunja & Kuyini, 2017), which is always in the form of change and transformation because such practitioners always develop a vision for empowering the social and economic status of the disadvantaged groups targeting to fulfill the uplifting interests including social conscience, intellectual excellencies and study of future by means of addressing their critical voice and designing the strategy for the management of the resources that acquired for this (Taylor, 2014). Thus, from the axiological perspective of my research, the value I attributed to the different aspects of my research, the participants, the information and the audience to which I reported the results of my research was in the transformative process, i.e., it was value-laden but in transforming process.

Moreover, post-modernism fosters me to assign value to the subjective and multiple opinions of the participants and communities instead of accepting the predetermined steps of action. In addition, it encourages me to argue personal, relational, historical, cultural, conditional and incomplete values instead of assigning the values to the opinions of expressing fixed, universal and certain ideas (Grenz, 1996; Linstead, 2004). As my purpose in this research is to empower engaged learning in mathematics through a project-based learning approach, the efforts of each research participant made in learning were assigned value individually. It was individually different as post-modernism practitioners agree each diverse and different individual has its own value.

Multi-Paradigmatic Research Design Space in My Inquiry

Based on the nature of my inquiry, I engaged in qualitative research. In my research, I articulated my learning worlds using dialogue, poems, and narratives in one hand. On the other hand, I intended to change my professional practice as a teacher through critical reflection on my existing practice through this inquiry. I did not find a single research paradigm to address the concepts of my inquiry. Therefore, I used a paradigmatic research design including interpretivism, criticalism, and postmodernism research paradigms.

Moreover, interpretivism enabled me to have an in-depth understanding of participants' cultural situations, beliefs, and the process of shaping their normative social and contextual practices in my inquiry (Taylor et al., 2012) since my research participants were of diverse cultural and social backgrounds from different circumstances with the creation and experience of different social realities. Likewise, I was assisted by criticalism to bear a critically reflected role since critical researchers aspire to adopt an interventionist role and redress practices (Taylor et al., 2009). Besides, it supported me to critically reflect on my daily practice and to shift it into engaged learning. In similar reasoning, to unpacked my learning journey in artistic nature using the poem, pictures, dialogue, narratives, etc. I was fully cooperated by post-modernism.

Research Paradigms

It is found that the term paradigm in research is initiated by means of the Greek word *paradeigma,* which signifies the *pattern* applied in inquiry. At first, the word was initiated by Thomas Kuhn (1962) to represent a conceptual framework model that identifies problems and its solutions based on the ideas shared by a group of scientists. Indeed, it represents a common set of beliefs, values and assumptions of

the group investigators regarding the culture of nature and ways of conducting research (Kuhn, 1977). Besides, it mainly concerns the collection and organization of such logical concepts and propositions which frequently provide the theoretical guidelines for conducting the inquiry in appropriate ways based on selection (Amukugo, 2002). Thus, a paradigm in an inquiry refers to a guideline representing a framework or system of scientific and academic ideas, beliefs, values and assumptions required to complete research. (Olsen et al., 1992). Under this, I have mentioned research paradigms from which I was empowered to complete my research study.

My Research Paradigm: Interpretivism

As my research purpose was to explore how engaged mathematics pedagogy through project-based learning can be envisioned for Nepali schools, it demanded subjectivity, understanding and experience of an individual participant or their group to some extent. For this, the research paradigm interpretivism facilitated me to engage in the research field to understand my research participants from different perspectives. As the interpretive paradigm focuses on the experience and perception of individuals, which lets researchers interpret the world through the experiences and perceptions of the participants in particular backgrounds (Thanh &Thanh, 2015), it helped me to explore the viewpoints on STEAM projects in mathematics classroom based on the engagement, experiences and responses of the participants of my research. Besides, it encouraged me to put analysis in context (Reeves & Hedberg, 2003) with the creation of rich understandings and discussions of inquiry contexts during my study.

Moreover, it became helpful in my research to apply STEAM projects appropriately in mathematics teaching with the active engagement of diverse

participants of various backgrounds. Thus, this paradigm encouraged me not only to perform context-based rich understanding of participants' thoughts, beliefs, values and related social activities (Taylor et al., 2012) but also focused me on understanding the cultural variations of the participants and their effectiveness in learning mathematics focusing the participants to "stand in their shoes, look through their eyes and feel their pleasure or pain" (Taylor & Medina, 2011, p. 5). Moreover, this paradigm assists me in proceeding with my inquiry process, focusing on its complexity, richness, multiple interpretations, and even meaning-making (Saunders et al., 2009) for subjective reality.

Besides, I attempted to understand the phenomenon of my investigation by means of the combined efforts of participants such as based on their language, interaction, communication and overall contextual environment (Klein & Myers, 1999). My research participants agreed that truth and reality are established by social efforts rather than discovered. It means the participants did not directly accept external reality without being examined by them (Rehman & Alharthi, 2016) in their own efforts as the contribution of interpretivism. Therefore, in the completion of my study, by entering the social world of my participants and understanding it in their own view with the adoption of an empathetic stance, I felt full support from interpretivism.

My Research Paradigm: Criticalism

As my research was intended to explore how engaged mathematics pedagogy through project-based learning can be envisioned for Nepali schools, it contributed to my development as an empowering teacher. For this, the paradigm of interpretivism was not enough to address the challenge of empowerment (Taylor & Medina, 2011) in my research. The critical research paradigm was found helpful in addressing my

issue of inquiry by enabling me to practice ‘deep democracy’ (Kincheloe & Mclaren, 2000, as cited by Taylor & Medina, 2011). Moreover, the critical paradigm helped me identify the problem faced by the students in learning mathematics as a subject due to its de-contextualized nature from their everyday life and how teachers can facilitate making mathematics a “*subject of everyday life*” as well.

Moreover, through the critical paradigm in my research, the participants produced and reproduced reality by encouraging self-consciousness with the development of emancipatory consciousness in them (Kincheloe & McLaren, 1994). Besides, the critical theory sought to raise the sound against the weak points of hidden curriculum or text. It empowered the participants to search for the truth and contextualized understanding within their social context. According to Taylor (2014), “Central to the critical research, paradigm is a transformative intent to promote social justice, with practitioners acting on the world to make it more democratic, fairer, more equitable, more inclusive” (p. 15). Thus, it supported me in treating the research participants and myself as the change agents.

In my study, I was an instigator and facilitator (Guba & Lincoln, 1994) instead of empowering students to construct the concepts from the existing social world and perpetuate the knowledge status quo (Kincheloe, 2008) through critical theory. It assists me in the dialogic and dialectical nature (Guba & Lincoln, 1994) of inquiry. I am inspired to create an environment of emancipation where all participants get the opportunity of developing a critical conscience and civic-mindedness (Taylor et al., 2012) through engagement in dialogue to change their perception of learning mathematics. In addition, I used the critical paradigm in the research as it clarifies the researcher’s role as one of advocacy, a change agent to develop a more equitable, fair and sustainable society.

My Research Paradigm: Post-modernism

Post-modernism diversely treats everything based on its value. Therefore, it rejects the concepts of the existence of unity as well as universality. Indeed, this paradigm empowers me to express my experiences and feelings through different ways of communicating, such as language, art, narratives, gesture and so on (Taylor & Medina, 2011) in my research. According to this paradigm, all knowledge, including scientific knowledge, is socially or consensually constructed by the participants in the process of continual reflexivity. Therefore, no knowledge can be objective and universal (Freedman & Combs, 1996); however, there are different socio-cultural situated knowledge in each society (Freedman & Combs, 1996). According to its matching, this knowledge is used in a particular context, time and space. Such knowledge directly affects learning mathematics as well in their own context.

According to postmodernism, the truth cannot be universal and is for a specific community according to the community's cultural, social and individual aspects. Moreover, from the postmodernist perspective, postmodernists raised questions regarding all established truths and realities that are based on social rules, criteria and empirical results (Glanville, 1993) instead of applying expert knowledge. In addition, raising questions is the major feature of the postmodern vision. In this paradigm, raising questions is open, and all participants are free for this as the reflection of meta-narratives of modernity (Lyotard, 1984), where the narratives of modernity are driven by the reflection of people’s cognitive ability or daily activities. Besides, the approach of questioning digs out in-depth meanings of narratives. Therefore, such activity of questioning in my research by means of postmodernism enabled me to figure out the meaning of the stories told by the participants.

Furthermore, it assisted me in completing the inquiry by accessing the multi-dimensional world of arts-guided inquiry (Taylor et al., 2012), linking with the new genres to investigate and communicate the real condition of participants regarding mathematics learning. Besides, postmodernism encouraged me to apply dialectical, metaphorical, narrative, and poetic logic (Taylor et al., 2012) in research for the contextual and multiple facets of knowledge and knowing and empowering holistic understanding of the world even while generating a conclusion.

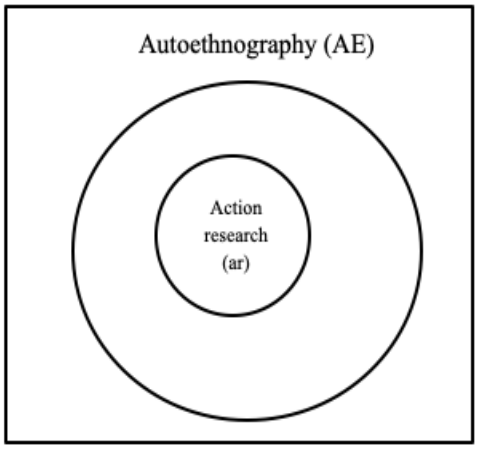
Moreover, it flourishes the other disciplines, such as arts in educational research, by introducing many new forms of writing, such as impressionist writing, autobiographical writing, narrative writing, poetry, ethno-drama, screenplay and fiction using literary genres as well as visual genres, such as film, painting, sketching, dance and photography (Taylor & Medina, 2011). Therefore, I was encouraged by this paradigm due to such multiple supports in the completion of my research.

Likewise, from the perspectives of multimodal, cross-disciplinary, trans-disciplinary, and multidisciplinary as it includes performative genres such as music, drama and dance, visual arts (collage, paintings, photographs, sculptures and so on.), and narratives (Denzin & Lincoln, 2018); this research paradigm I found as the guideline to me even for the meaning-making process.

My Research Methodology: Autoethnographic Action Inquiry

Generally, the research methodology refers to the process through which the researchers describe, explain and predict the phenomena. I have taken autoethnographic action inquiry as my research methodology in this research. I have completed this research from a major approach of sharing my culture of learning the world through narratives, poems, dialogue, diagrams, etc. I explored in detail and tried to make it meaningful of my experiences of the academic world as a learner and as a mathematics teacher. In this inquiry, I have tried to make a reflexive connection between my stories, my context and myself. For this, autoethnography assisted me because employing autoethnographic writing inspired me to think deeply about my experiences (Lac & Fine, 2018) of my academic journey.

Figure 2
Interpreting My Research Methodology



Moreover, I have used autoethnography as a tool (Acosta et al., 2015) for investing the problem under my inquiry based on my experience and context. Likewise, based on my experience of the disengaged and decontextualized practice of learning and teaching mathematics, I have attempted to shift my pedagogical approaches using STEAM projects to promote engaged project-based learning in this inquiry. In other words, action research in my inquiry supports me in developing the vision of transformation through the researcher's awareness, reflection, and behavior integration (Merriam & Clark, 1991, as cited by Acosta et al., 2015). Thus, to

complete this inquiry, I took autoethnographic action research as part of the methodology.

Autoethnography (AE)

I have demonstrated my own experiences as a learner as well as a teacher through narratives. In this inquiry, my mathematics learning experience is shared through diverse viewpoints, focuses and meanings that incorporate both the researcher's and participants' journeys and their transformations through experience (Jones, 2006). Under the application of the autoethnographic methodology, I have included the experiences of my learning world mainly from three different lenses: my personal, spiritual, and academic lens, since they have influenced my life and my thinking. In addition, while exploring my experiences by means of autoethnography, "it involves a back-and-forth movement between experiencing and examining a vulnerable self and observing and revealing the broader context of that experience" (Acosta et al., 2015, p. 413).

Furthermore, auto-ethnography empowers me in my self-reflection for expressing experiences in the form of narrative writing, and qualitative inquiry (Chang, 2013) in my research, such as I have started to unpack my personal lived experiences as a conventional learner at first. After, I explored my lived experience as a teacher in the way of transformation. Because of my schooling environment, I was unable to develop a fully engaged learning environment in my classroom practice at the beginning of my professional life; however, I intended to apply student-centered pedagogical practices. By means of inquiry, I have developed a vision of engaged learning. For this, AE has boosted me in the proper direction and provided me a research tool in my inquiry that allowed me to systematically investigate a problem related to my practice such as in my professional identity (Acosta et al., 2015).

Besides, it enables me to know myself as I observed myself as both learner and teacher to determine what is real within me from my early phases of childhood, my schooling until my present M.Phil. learning in adulthood.

Furthermore, my research methodology autoethnography has focused on my own story, on myself within a larger context (critical autoethnography), myself acting in my educational contexts (self-study and empowering teacher), as well as myself acting according to the values that I lived in my context (action research). Keeping these concepts in mind, I have focused on observing the setting, culture, and participants of my inquiry and then reflecting on my interactions (Hamilton, 2018). Likewise, I have used autoethnography in my research to demonstrate a radical departure from the positivist notion to the transformative notion since it subscribes that reality is established based on the reflections of the researcher's experiences in their (Spry, 2006). Furthermore, it empowers transgressive ways of knowing, including interpretation, self-reflection, deconstruction and evocative storying, all arising mainly from interpretivism, criticalism and postmodernism (Luitel, 2009). I reflected on my experiences in my research as a student, mathematics teacher and teacher educator through autoethnography, which is a significant aspect of my research.

Furthermore, by using autoethnography while writing narratives of experiences, I made many attempts of revision after revision until I examined the events, my feelings, and thoughts deeply and thoroughly (Lac & Fine, 2018). Such attempts led me to gain more insight and possibilities for making my experiences lively and communicating evocatively to readers such that they might (re)consider their own lives in the light of their learning world. Next, I am pooling my stories so that the readers can find similarities and distinctness to point out the meanings of the

stories relating to the sociocultural contexts (Arnold & Norton, 2021) and what they felt.

In my research, I employed the technique of narrative inquiry to explore, interpret and generate the agenda of inquiry that are arisen due to the sociocultural and professional contexts by which I was guided. For this, I have found autoethnography as the best methodology. In addition, autoethnography is a useful method that I found appropriate for fostering creative and rich understandings of issues in my study (Luitel, 2009). On the other hand, it empowered me to employ the inquiry using arts (Barone & Eisner, 2006) in my research.

The autoethnographic text under my inquiry helped me with deep reflections, insights, and critiques that signifies about how I approach this inquiry (Lac & Fine, 2018). I was assisted by autoethnography in my inquiry to create performative arts such as poems, pictures and narratives of my lived experiences as a student, a teacher and a teacher educator (see chapter- IV). Doing so, I ensured that I employed autoethnographic writing in my inquiry to think deeply about my experiences (Lac & Fine, 2018) of educational pedagogy.

Action Research (ar) in Autoethnography (AE)

However, I have taken autoethnography as the major research methodology of my inquiry, to transform my professional practices, I have employed action inquiry as a turning part of autoethnography. Since “action research is a name given to a particular way of researching a researcher’s own learning, it is a practical way of looking at a researcher’s practice to check whether it is as he/she feels it should be” (McNiff & Whitehead, 2002, p. 15). I believe that it assists me in identifying and solving the problems existing in my professional activities through research. I have

used it to solve an immediate problem by integrating research, action, and analysis to empower me to seek transformations in my practices (Brown & Dowling, 2001).

As it is often referred to as practitioner's research, or practitioner-led or practitioner-based research (McNiff & Whitehead, 2002), I have chosen it to improvise in my practice of professional life. Moreover, using action research in my inquiry allowed me to demonstrate my practice, my understanding of it and the conditions under which the practices are undertaken (Arnold & Norton, 2021). Likewise, I have conducted this research to improve my professional practice (Hamilton, 2018), i.e., self-improvement perspective. Also, it has helped me empower learning toward reflective processes that enable self-evaluation of my values, beliefs and experiences. It involves critical reflection and dialogue in teaching and learning (Gravett, 2004) through the involvement of participants by examining, enhancing and converting into reflective and constructive discourse such that alternative viewpoints for solving the problem are discussed and assessed through dialogue.

As McNiff and Whitehead (2002) argue that action research has always to do with learning, and learning is to do with education and growth, my choice under this action research as the minor research methodology in my research was to be an updated transformative practitioner in my teaching-learning practices. For this, I have chosen four phases of action research mentioned by Burns (2015) based on the idea of Kurt Lewin (1946), who analyzed the process of action inquiry in a cycle of planning, acting, observing and re-formulating/reflecting the plan for my research study. However, I have completed a single cycle of these steps as I am taking action research as the minor methodology.

Planning

It is the initial phase of action research. I have designed some projects (see annex D) related to my research purpose to teach mathematics based on STEAM disciplines for engaged learning of my participants. I also planned to observe or monitor my proposed changes (Burns, 2015). To design STEAM projects, interpretivism and post-modernism supported me (see chapter V). I have planned (see annex D) carefully regarding the judgment of the intended type of knowledge, the appropriate technique of evaluation that I need to follow, preparation of the interview guidelines (see annex A) and interview schedules or other appropriate observation frameworks and even for overall research.

Acting

Based on my plan and design of the STEAM-based projects by addressing my research purpose, I have acted (Burns, 2015), i.e., the STEAM projects were used practically in my classroom practice fostering the engagement of participants towards learning mathematics through virtual mode (see chapter VI). I found interpretivism helpful in acting according to students' interests and levels. Likewise, criticalism supported me in implementing projects and creating dialogue, and post-modernism became helpful in designing the project and acting through it artistically.

Observing

I have used various means for exploring the purposed change that occurred from the planning and acting, i.e., designing and implementing STEAM-based projects in teaching and learning mathematics such as I have taken unstructured interviews virtually, I have given assignments/project works (see annex E) based on it, and even I have used other ways of observations during all time of research process such as using logbook, diary, memo, etc. being guided by the idea of Burns (2015).

Moreover, detailed observation, monitoring and recording were planned and done in the process of implementation of projects in my research. As a result, it enabled me to feel the effect of my action or intervention. Besides the planned observations, additional essential observations were made and then gained insights into the participants were recorded regularly during my research study.

Reflecting

As the idea given by Burns (2015) that the regular reflection at the end of each action cycle is an integral feature of action research, thus, after the observing phase, my effort was to reflect the change based on acts, experiences and observations for each STEAM project more critically. For this, I have used different criteria and prepared an evaluation sheet (see Annex F) based on it. However, I have used the single cycle of these steps of action research in my research study as I have taken action research in the minority of my study. But I have made a tiny effort in designing the projects according to the needs and interests of participants guided by the existing mathematics curriculum as well.

Research Site and Participants Selection

As my research design is an autoethnographic action inquiry, I am the research participant for autoethnography. Next, I have chosen the specific research site and participants in this section to complete the criterion in an action inquiry under my study. As my research topic was "Envisioning Engaged Mathematics Pedagogy through Project-Based Learning for Nepali Schools: an Autoethnographic Action Inquiry," I considered various factors (availability of technological devices, activeness of participants, supportive and familiar environment, etc.) for the success of the study. Besides, I have conducted my research work virtually due to the pandemic situation of COVID-19. Thus, I have chosen this research site in

Mahalaxmi Secondary School[17] of Kathmandu municipality; where I am working primarily as a teacher and teacher educator in mathematics. Moreover, I have chosen this site for improvising pedagogical practices as a transformative practitioner. Doing so, I found that it is accessible for me in terms of location, time, resources management and other professional relations as a mathematics teacher at this school.

The selection of participants of the study is another important part of the study. As Dahal (2014) argues that qualitative research focuses on a relatively small number of participants, which is selected purposefully that may easily answer the research question; so, I have chosen 30 students of grade IX of Mahalaxmi Secondary School located in Kathmandu as the research participants of my study by purposive selection technique.

Data Collection and Generation Approaches

I used autoethnographic action inquiry as the research methodology to complete my inquiry. For this, I have attempted two means of collecting information. I have explored my experiences by means of storied text to conduct the autoethnographic inquiry. I have unpacked different sources of collecting information for the action inquiry part of my inquiry. These are both discussed in this section.

Envision of Narratives: Data for Autoethnography

As an autoethnographic researcher, I tried to unpack my lived experiences regarding my learning mathematics from the beginning of school to the MPhil level as well as in the form of narratives. However, it was not easy for me to present it in a way that made true sense of my research topic. In the process, I documented the vivid experiences that I gained in the learning journey of different classes and levels then I

[17] Pseudonym of a secondary school of Kathmandu valley.

chose to present these experiences by means of narratives under autoethnography. During this journey of writing, I was inspired by the educational empowerment of the MPhil level launched by KU on the one hand. On the other hand, my real-life issues made me compulsory to feel that. Anyway, such experiences became a milestone for me in the deep understanding of my culture of learning mathematics and encouraged me to be a transformative professional practitioner.

Moreover, through the use of narratives of my learning worlds, I have become more aware of my past and more critical of my present practices. In doing so, my present and past experiences pointed me out for future professional practices. I ensured that the presentation of my narratives helped readers capture the theme and understating realities of the educational pedagogy depicted in my storied texts (Luitel, 2009). Moreover, I tried to write my living stories to address the research agenda. For this, I used different writing genres, such as stories, dialogues, poems, metaphors, pictures, etc., under the postmodern paradigm that reflects my economic, sociocultural and contextual learning environment. I have demonstrated my critical reflection on my past learning and lived experiences to enable myself to understand and even others in their context under the different genres of writing to make meaningful narratives guided by autoethnography.

Furthermore, in addressing the research purpose and questions, I chose only relevant, most memorable, meaningful and contextual lived experiences under this research as the base of my narratives. In doing so, I tried to make it more meaningful with the feeling in my mind that the narrative inquiry and artistic presentations impact both the process and product of the inquiry as the means of retrospective meaning-making (Chase, 2005, as cited by Luitel, 2009). Besides, I depicted my role as a

passive learner, reflective learner, conventional teacher, and transformative teacher to improvise pedagogical practices under my storied texts.

My narratives explored my experiences using different textures representing different features of conventional, cultural and existing pedagogical practices. This does not mean that I am giving an informatic way of narratives. I have given a key message to people of similar contexts to reflect critically on their experiences and change in their daily practices. In addition, I developed separate chapters as the requirement of the research questions I designed according to the purpose of the inquiry with reference to the guiding theories and well-established concepts for each subsidiary research question to strengthen the concept and generate a meaningful theme under my inquiry.

Data for Action Inquiry

To generate information from participants regarding the application of STEAM projects in learning mathematics, I prepared and used interview guidelines (see Annex A), focus group discussion guidelines (see Annex B) and google form (see Annex C), including an open questionnaire to collect data and to fulfill the part of my action inquiry. I have prepared guidelines connecting with research questions to achieve the research objective. Besides, I observed my participants' activities, responses, activeness and collaboration during the research process. I noted it in my memo and diary to enrich data collecting based on my research agenda.

Unstructured Interview

I have taken unstructured interviews online as a means of information collection. I have gone through the flow of conversations and created the questions before, in between and end of the implementation of my STEAM projects in the mathematics classroom. I have tried to explore newer ideas, not the general

description building rapport with the participants by listening to their stories of survival, cultures, practices, experiences, knowledge, etc. Moreover, my research interview was taken as an exchange of ideas freely through regular conversation (Busetto et al., 2020), with the participants taking the research objective in mind as well.

In addition, I have encouraged them to explore the broad areas of interest (Busetto et al., 2020) to my participants through seven open-ended questions (see Annex A) and the use of an interview guide and sometimes including sub-questions even. The information thus obtained, I regularly noted in my diary. Also, I recorded the interview by taking the participants' permission, making them clear about the aim of completing my research agenda. Indeed, I felt my informal, conversational interviews are ideal, with open-ended questions supporting me to gain rich and detailed context of my participants.

Observation

As observation occurs simultaneously with interviews/conversations (Hammersley & Atkinson, 1995), I continuously made the research purpose-oriented virtual observations during the study period. My research took place throughout the field engagement, starting from field entry.

Since my research methodology was an autoethnographic action inquiry, so it demanded keen and careful observation of everything in the field. Students' engagement towards mathematics learning was observed through different means such as assignments, virtual tests, google forms, etc. Indeed, through observation, it is possible to collect open-ended and firsthand data. During my study period whatever I observed were all noted in a memo as well as I prepared short notes for use in my research while analyzing the information.

Focus Group Discussion (FGD)

I categorized 30 participants into five groups of similar nature, including six participants in each group for virtual discussion. Keeping in mind that the focus group interviews are taken to explore participants' expertise and experiences (Busetto et al., 2020), I allowed them to discuss their true feelings in their own words in a relaxed atmosphere with audio or video-recording, note-taking, etc.

Since the focus groups are an easy, fast and in- expensive technique of gaining information through group interaction, i.e., "the sharing and comparing" among participants (Busetto et al., 2020, p. 3), I encouraged my participants to speak and discuss in the group such that they can easily express their view regarding what they were feeling from the application of STEAM projects in learning mathematics. For this, I prepared a focus group discussion guideline including twelve open questions (see annex B). Moreover, I facilitated or moderated in an unbiased way rather than direct or controlled conversation. I took note of key ideas shared and discussed by the participants from recording their discussion with the participants' permission.

Diary and Logbook

I have used a diary and logbook as another means of collecting information to keep a record of my lived experiences, daily activities, assignments based on classroom activities, etc. Moreover, I used a diary and logbook as the "personal account (usually but not necessarily private) recording observations, ideas, interpretations, feelings, reactions, hunches, speculations, explanations, and reflections regularly around topics of interest or concern" (Kemmis et al., 2014, p. 177), these all behaviors were observed through virtually in my study. Thus, through a diary and logbook, I kept supportive information about my research during the implementation of projects in the mathematics classroom.

Google Form

I developed a google form including five open questions to explore participants' in-depth ideas and experiences about project-based mathematics learning by means of STEAM projects (see Annex C). It was given to the students to fill out right after the completion of each day's classroom activities. By means of these open questions, I felt very easy to explore the participants' ideas, thoughts and experiences during my study.

Multiple Meaning-Making Process

As I have used autoethnographic action inquiry as the research methodology of my inquiry, I have generated the theme of my research from two perspectives: autoethnographic and action inquiry under this section.

Research Logic and Genre

It is challenging to unpack my experiences in the form of narratives to address the research agenda through a single way of expression on one hand. On the other hand, the ultimate requirement of my writing narratives is to enable readers to sense-making by grasping the ideas shared in the narratives. For this, I have used different logics and genres (such as narrative, dialectical, poetic, metaphorical and non-linguistic) for writing narratives promoting the postmodernism paradigm in my inquiry. I have critically reflected on my lived experiences of learning and teaching mathematics based on my contextual phenomenon and memories by logic and genres. Such different forms of expressions that explored my experiences in my inquiry embody multiple logics and genres (Taylor & Medina, 2011), which are mentioned as follows:

Narrative Logic and Genre

I portrayed my multi-layered and multi-stages learning experiences of mathematics by means of storied texts, i.e., narratives, in this study. Besides, narrative logic is taken as "a means for conceiving research process in terms of the chronological evolution of events, research foci and emergent questions" (Luitel, 2009, p. 50) in my inquiry. As Luitel and Dahal (2020) stated, I used narrative logic and genre to demonstrate contextual accounts arising from my actions in my learning at first and then teaching mathematics. Moreover, it helped me to envision my personal lived learning world meaningfully on the one hand. On the other hand, it directed me on the transformative path of teaching and learning mathematics in my professional life (see chapter IV).

Dialectical Logic and Genre

I used dialectical logic and genre to critically reflect on my lived experiences by developing a sensitivity to controversial issues in my inquiry (Luitel, 2009). It is necessary to reduce dualistic logic embedded in pedagogical practices for the integral and holistic teaching and learning approach to learning mathematics. This dialectical logic and genre are taken as the means of this study. Moreover, this research logic and genre empowered me to develop a vision of a holistic and more inclusive pedagogical approach in teaching and learning mathematics beyond the dualistic and exclusive practices that I experienced in my learning world. Besides, by adopting a multi-paradigmatic design space (Luitel, 2009) in my study to respond to my research agenda, I was assisted by this logic and genre.

Metaphorical Logic and Genre

I explored my contextual experiences by means of metaphorical logic and genre for the purpose of making a thematic understanding of the meaning of my

concepts and ideas that are unpacked in my storied texts (see chapter IV). The ease of capturing a phenomenon's complexity (Luitel, 2009) enabled my inquiry. Moreover, I employed it in the writing journey of this inquiry, being more critical and emancipate in the sense that it assisted me in depicting the complex nature of my study. In my inquiry, it also clarified the sense of the narrated texts in the beyond of narrow literalism.

Poetic Logic and Genre

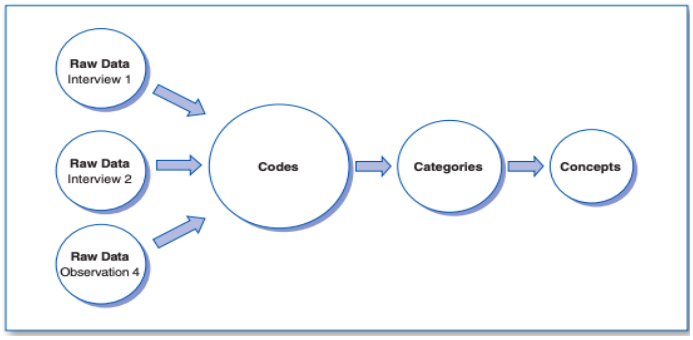
I used poetic logic and genre to express my experiences based on my memory and imagination, supporting with post-modernism paradigm in my research. It is useful to me for expressing emotional, aesthetic and spiritual feelings (Shakotko & Walker, 1999, as cited by Luitel, 2009) under my inquiry. Moreover, I explored multiple interactive and imaginative aspects of the pedagogical reality of my learning world (Luitel, 2009) by means of poetic logic and genre in the different sections of my inquiry that I experienced from my academic world such that it supported me to envision the research issues from multiple perspectives in the sense of responding research questions as well.

Non-linguistic Genres

I employed non-linguistic genres by means of including photographs, screenshots of videos and collages in my inquiry to demonstrate the multi-vocal, embodied and nonlinear nature of the knowledge gained from my academic journey (Luitel, 2009). Moreover, such visual imaginations in my research foster clarity in articulating the claimed knowledge and in the meaning-making process. In my inquiry, I have included such non-linguistic genres (photographs, screenshots of videos and collages) based contexts and meanings for completing the research in arts-integrated form, capturing the real educational phenomenon.

Since I have taken action inquiry inside of my autoethnography as my research method, after collecting the information for my study, I transcribed all the oral information, audio and video recording. Also, I used the information noted in the memo, diary and logbook. As a qualitative researcher, I started analyzing information from the beginning of information collection as a regular process (Flick, 2009, as cited by Dahal, 2014). I was regularly collecting, transcribing, coding, categorizing and reflecting on concepts from the beginning of the study, as shown in figure 3.

Figure 3
Theme Generating Process



Moreover, I have constructed meaning by reducing the raw information obtained from participants into significant information with the appropriate pattern along with interpretations, including key findings and the meaning of narratives. Also, I have observed and listened to participants' views and experiences regarding the new technique of learning (use of STEAM projects) in learning mathematics, asking other relevant questions for collecting pertinent ideas from participants to create narratives. My meaning-making process fully depended on theme generation based on raw information collecting, transcribing, coding, marginal notes, clustering themes and self-reflection, i.e., the meaning-making process was based on a general qualitative research pattern. The overall research process is summarized in the following table.

Table 1
Chart for Data Generation and Meaning-Making Process

SN	Research Questions	Sources of Data	Timeline	Meaning Making	Quality Standards
1.	How have I connected with disengaged mathematics learning?	Narratives of my lived experiences of learning world	▪ Learning journey from school education to Master degree in Mathematics Education (1990-2009) ▪ Professional journey as a teacher and teacher educator (2004 -2019)	Narratives, dialectic, metaphoric, poetic and non-linguistic logics and genres	Verisimilitude, transferability, pedagogical thoughtfulness and
2	How did I develop the notion of project-based pedagogy for engaged mathematics learning?	Guidelines and references provided by professors in the classroom and related scholarly efforts of some authors at the MPhil level in STEAM education	During MPhil level in STEAM education (2019 - 2020)	Inspiration of professors' arguments and self-critical reflection	critical reflexivity
3	How is my implementation of project-based	Field notes, narratives, observations, interviews,	Project implementation in classroom (November 2020)	Transcribing, coding, categorizing and concepts formation	Credibility, transferability, dependability and

	pedagogy in learning mathematics?	FGD and google form			confirmability
4	How have I and my students reflected on the outcomes of the project-based pedagogy?	Researcher's and participants' reflections	During the implementation of projects in classroom learning (For participants- November 2020) (For researcher project implementation to till date)	Analysis of participants' reflections and self-critical reflection)	Verisimilitude transferability, pedagogical thoughtfulness, critical reflexivity

Trustworthiness: Quality Standards of My Research

In my view, ensuring quality standards (trustworthiness) is needed in the overall process of research work. However, Guba and Lincoln (1985) focused on the research findings. The main purpose of trustworthiness in qualitative research is to support the argument that the results obtained from the inquiry are "*worth paying attention to*." Furthermore, trustworthiness deals with examining the authoritativeness of data analysis, reports and interpretations in constructing knowledge (Burns, 2015), i.e., it reflects the quality of the research findings.

As an interpretive autoethnographic researcher, the quality of my research depends on the narratives I portray in this inquiry. For this, I envisaged a comprehensive account of my experiences by ensuring fairness, authenticity and meaningfulness in the storied texts. I assured the originality and contexts of the

narratives, demonstrating my multiple experiences being honest with the help of different criteria in this section. Moreover, I have discussed some criteria for maintaining quality standards of my autoethnographic research (such as verisimilitude, transferability, pedagogical thoughtfulness and critical reflexivity) that I ensured in the overall study together with the criteria outlined by Guba and Lincoln (1985): credibility, transferability, dependability and confirmability.

Verisimilitude

Verisimilitude is a criterion for writing narratives in real and alive form connecting directly to the readers in the study world (Creswell, 2007, as cited by Loh, 2013). Therefore, I developed my narratives by creating enough space for the readers such that they can be connected with my experiences internally and externally in their living world. Moreover, I narrated my lived experiences using multiple logics and genres such that the "audiences must experience a congruence with their own experiences of similar, parallel, or
analogous situations" (Blumenfeld-Jones, 1995, p. 31). However, I cannot claim the objective truth of my stories with others.

Furthermore, the quality standard verisimilitude is important in my inquiry since it allows readers to have a vicarious experience (John, 2013) when they feel a similar context. I have crafted my narratives very well such that it permits the readers' insights, deepen sympathy and empathy as well as encourage them the understanding my subjective world by means of my narratives. Besides, I have tried to resonate and to capture plausible to the readers while writing narratives in my inquiry to maintain verisimilitude.

Transferability

In general, the research activity or its findings are transferable or generalizable if it fits into other contexts also rather than the context in which the study was done. Moreover, Guba and Lincoln (1985) focused on the evidence explored by the researchers in their research about the generalization or transference of the findings to other settings, groups, or contexts. In my research, transferability examines the relevancy of my inquiry theme beyond the context of my study (Luitel, 2009).

To maintain this quality standard in my inquiry, I demonstrated the contexts, events and moments of experiencing decontextualized mathematics learning in-depth. Besides, to enhance it, a researcher can study in detail the research methods, research conducting contexts, and assumptions made in the study. Therefore, to ensure the transferability of the outcomes of my inquiry, I have unpacked complete ideas regarding the self and the context of the inquiry, inquiry processes, participants, and the relationship between researcher and participant (Morrow, 2005) as well. Therefore, it can apply to future researchers to investigate similar research agendas in a similar context.

Pedagogical Thoughtfulness

I attempted to address the quality standard and pedagogical thoughtfulness in my research, including evocative, perspectival and dialogic texts (Luitel, 2009) by means of multiple genres such as narratives, poetry, dialectic, non-linguistic and metaphoric. Being connected with my narratives, contexts, events and moments, I hope that it enables the readers to treat mathematics and its pedagogical practices from a new perspective (Qutoshi, 2019) in their professional world.

Furthermore, I ensured that my presentation of narratives in this inquiry evokes the readers to raise questions, reflect and examine the educational pedagogy

they have used (van Manen, 1991) in one hand. On the other hand, it supports teachers and educators in considering, realizing and updating their deep-seated values, beliefs and practices.

Critical Reflexivity

In my research, the quality standard and critical reflexivity are ensured from chosen epistemology, methodology, and theoretical referents (Luitel, 2009) in completing my inquiry. Moreover, my attempts in the research process enabled me to reflect on my practices, assumptions and beliefs critically and thus boosted me to enter into a transformative journey. Doing so enriches the inquiry's extent and facilitates the readers under my background information unpacked in the inquiry.

In addition, the quality standard reflexivity supports the readers of my inquiry to examine my self-consciousness critically and become aware of the selection of epistemology, methodology and theoretical referents. To ensure such standards in my research, I have attempted to interpret the research process clearly and visibly to the readers by reflecting critically on my assumptions and subjectivity through a critical research paradigm.

Credibility

Credibility refers to the linkage between the output of inquiry and the reality for examining the truthiness (Guba & Lincoln, 1985). In general, credibility is analogous to matching reality and the study's findings. However, the reality existing in qualitative research is relative to the meaning that the people construct it within their social contexts, i.e., it implies multiple realities according to the contexts.

In my research, the interpretive paradigm assisted me in that the reality of my inquiry is in co-constructed form and is not in objective form. Therefore, to maintain the credibility of the inquiry, I have prioritized the inclusion of members checking

into the inquiry outputs, i.e., taking feedback on the information, interpretations and reflecting from participants themselves and so on. Moreover, to ensure credibility in the whole process of my research, not only in the findings, I also prioritized the long engagement in the research field virtually with the participants, persistent observation of them, and even peer-debriefing of the participants.

Dependability

Merriam (1998) argues that "dependability refers to the extent to which research findings can be replicated with similar subjects in a similar context" (p. 205). As human behavior is contextual and changes continuously due to different influencing factors, to hold dependability in the research findings is generally difficult since it refers to the stability of information (Guba & Lincoln, 1985) over time and under different conditions. However, it is ensured "through carefully tracking the emerging research design and with a detailed chronology of research activities and processes; influences on the data collection and analysis; emerging themes, categories, or models; and analytic memos" (Morrow, 2005, p. 252). Moreover, it also depends on the construction of meanings from the qualitative research based on the researcher's individual experience and skill in gathering and interpreting information.

I have ensured the dependability of the research findings through discussions with experts, my supervisor and peers about methodology, process, design, interpretations, and generating themes. Also, I attempted to ensure that there was not anything missed.

Confirmability

Confirmability deals with the degree of confirming the outcomes of the inquiry. According to Guba and Lincoln (1985), it represents the degree of neutrality in the study's outputs. It focuses that the outputs of inquiry should refer to the

situation being studied instead of beliefs, pet theories or biases done by the investigator (Morrow, 2005). Moreover, Seale (1999) argues that “auditing could also be used to establish confirmability in which the researcher makes the provision of a methodological self-critical account of how the research was done” (p. 45). Therefore, in order to ensure confirmability in my research findings, I have provided an audit trail, which helped me in examining that the participants' responses are clearly portrayed by the outputs of my inquiry, i.e., I have ensured in my research that the research findings based on the participants’ narratives, words, conditions of the research rather than other biases, motivations and views.

Ethical Consideration

As a qualitative researcher, I have established in-depth interactions with the participants of my research in order to dig out the ideas regarding their domains of individual values, weaknesses, learning disabilities and the common interest to collect the required information. Moreover, it is required to investigate by entering the private spaces of their participants to generate reality from the investigation (Silverman, 2000). It demonstrates that in qualitative research, the relationship between participants and researcher plays a key role in the success of the study. These all interpret the ethical issues that are needed to address during the inquiry time as well as after the conduction of the inquiry.

According to Creswell (2003), the researcher should bear the responsibility of respecting the participants' rights, needs, values and desires. Therefore, I have taken all these aspects carefully in my research. Furthermore, ethical issues are of great importance in the research. I ensured ethics in my inquiry by maintaining the quality, value and democratic worth of the inquiry (Burns, 2015). Besides, “throughout all stages of qualitative research, the consideration of ethical issues is crucial to keep the

balance between the potential risks of research and the likely benefits of the research" (Mohd-Arifin, 2018, p. 31). Therefore, I was aware of these ethical issues in the overall research process from beginning to end. To ensure ethical considerations in my research, I have considered the following ethical concerns:

Informed Consent

My research refers to a voluntary agreement, i.e., permission from the participants. Burns (2015) argued regarding two types of permission: first, permission from the study field of the investigator and second, permission to obtain informed consent from the study participants. In my inquiry, I used both types of permission. Moreover, I have informed the purpose, nature, data collection methods, and extent of my inquiry before the commencement of research participants (i.e., students).

Furthermore, in my research, I have not taken written consent from my research participants, but the right to take ideas of the purpose, process and probable effects and the process of using inquiry (Burns, 2015) was equally provided to all participants. Also, adequate ideas about the inquiry, comprehensive information and the power of decision freedom were provided to all participants (Mohd-Arifin, 2018) in my research. Therefore, I ensured that I had taken perfect permission from the participants in the research process.

No Deception/No Harm

I have maintained vigilance regarding the possible output of the inquiry that can be occurred from the investigation to the participants (Burns, 2015). So, I have smoothly followed the no deception principle during the research study. It means I ensured that in my research study, the participants are secured in overall aspects such as physically, emotionally, socially, culturally and ethically. In other words, in my

research, I guaranteed that no participants might be harmed from any perspective, such as physically, psychologically and so on.

Confidentiality

In my study, the anonymity and confidentiality of the participants were ensured by keeping their names and identity secret at the time of collection (Mohd-Arifin, 2018). Moreover, as a qualitative research practitioner, I have tried to avoid confidentiality dilemmas to generate rich and in-depth information from the participants. To ensure the confidentiality of participants in my research, I have used pseudo–name instead of their actual names, and the information in different stages of research such as information about achievements, cultures, lifestyles, etc., were all secret.

Bridging to the Next Topic

With the purpose of completing my study, I have explored the philosophical dimensions, research paradigms and research design as the autoethnographic action research that guides my research. Moreover, to address the problems raised by research questions, the required research site, participants, methods of collecting information and the process of generating a conclusion based on the research design are all included in this chapter. Besides, the possible criteria for maintaining the reality of the derived conclusions of the study and participants' secrecy from all aspects are also included in the chapter. As a whole, I have outlined the framework of my research process in this chapter. With this inclusion, to reach the final theme, I have tried to answer the first research question in the next chapter. For this, I have explored my feelings and lived experience as a student at the school level, college level and MPhil level in one hand. On the other hand, I have explored my feelings and experiences as a teacher at the beginning of my professional journey and as a

transformative teacher after some years of learning the journey of M.Phil. level of KU as well narratives inquiry and poetic expressions.

Chapter Summary

This chapter has outlined the overall research design and research process regarding how the research study was conducted. Moreover, I have mentioned the philosophical dimensions, research paradigms, methodologies, strategies and design of the study, including research site, participants, means of collecting information, theme-generating procedure and different criteria of trustworthiness as well as ethical issues.

In addition, I have included the meaning of ontology, epistemology and axiology according to my inquiry. The reasons and relevancies behind choosing interpretivism, criticalism and post-modernism as the research paradigms in my research are also explored in this chapter. Likewise, I have chosen autoethnography as the research methodology and action inquiry to bring change in professional practices. Furthermore, choosing the study area, participants and purpose of selecting it, various virtual means of collecting information and the systematization of such information and procedure generating theme using multiple logics and genres for the autoethnographic part and for action inquiry part mainly transcribing, categorizing and concept forming are outlined in the chapter.

Criteria for ensuring the quality standards of my research findings and my commitment to participants for ethical issues before, between and even after my study are also explored in the chapter in-depth.

CHAPTER IV

MY STEPS IN DISENGAGED MATHEMATICS LEARNING

Chapter Overview

By this chapter, I have explored my lived experiences and feelings guided by the questions: how was I forced to learn in my school-level education? How were my teachers motivated to learn at that level? What was my position while learning school-level education? What was my effort in learning? Likewise, how my academic journey started at the university level? What were my expectations while I was a student at the university level? How did I complete my academic years up to the master's level? How was the journey to the MPhil level started? How was I empowered in my learning journey? What were the differences between the learning approaches of the MPhil level and the master's level?

Moreover, I have envisaged my narratives based on the memory and contexts of my lived experiences as a student of different levels, from primary education to M.Phil. level, under this chapter. Doing so, I have attempted to explore real contexts, events and moments of my educational journey as far as possible as the demand of autoethnography. I have critically reflected on my experiences of mathematics teaching and learning. I have demonstrated rich voice indirectly for a pedagogical shift in my daily practices as a student and teacher.

Likewise, I used narratives, poems, dialogue, pictures, metaphors and monologues to strengthen my argument in addressing the research agenda and reaching a final conclusion. For this, I have included my lived experiences by dividing them into four sections: *Throwback to School Life, Throwback to College Life*, *Unforgettable Learning Journey of M.Phil.* and *My Role as a Teacher Educator*.

As a whole, I have made a tiny effort to answer my research question ‘How have I connected with disengaged mathematics learning?

Section-I: Throwback to School Life

I grew up in a family where my parents weren’t formally educated but were aware of the immense value of education. They wanted to bestow in me their dream of being educated. I was admitted to grade one at a primary school near my house. I spent 5 years in the school. I learned in a multi-grade system of learning with the set of classes 1, 2 and 3 together and 4 and 5 together due to the lack of resources for individual classes. It was virtually impossible to set up a productively interactive classroom thereafter. Talking about mathematics learning specifically in the early classes 1, 2 and 3, simple problems related to the concepts of fundamental operations (addition, subtraction, multiplication and division) were taught by attempting a number of problems given by teachers and proceeding it via rote memorization.

Figure 4
Memorizing My Multigrade Learning

Source: https://niice.org.np/wp ……

Moreover, the basic multiplication table was taught by seniors (students of classes 4 and 5) by rote memorization after tiffin time - particularly during the last and second last periods. Similarly, later classes 4 and 5 divided our duties into two categories. First, we were bound to follow the strict rules of the teacher in learning mathematics through the textbook to get a decent score in the examination. Second, in

later hours of each day, it was necessary to teach the multiplication table to the juniors, i.e., students of classes 1, 2 and 3. The final examination of grade five was at the district level. Thus, my attention and my teacher's effort together forced me to get a decent score in DLE (District Level Examination). However, I did not get the opportunity to learn mathematics with an awareness of its practical applications. Probably, the poetic expression alongside gives a glimpse of how I learned mathematics in my primary education.

MY LEARNING STYLE

Repeat! Repeat! Repeat!
Until you don't remember it.
Read! Read! Read!
Until you don't understand it.
Practice! Practice! Practice!
Until you can't vomit it.
Keep it! Keep it! Keep it!
Until the goal isn't achieved.

A deeply rooted traditional concept guided me - *practice makes a man perfect*. As a result, from the germination phase of learning, I was empowered in *pipe pedagogy* (Luitel, 2009) of learning mathematics, where only the teacher's voice is prioritized. I did not imagine any alternative way of learning mathematics. I did not consider the interdisciplinary aspects of mathematics while learning it. We referred to our teachers as *maths teacher*, *nepali teacher*, *science teacher*, and so on - integration of subjects was not seen.

Furthermore, instead of communicating between teachers, students as well as peers, our teachers used to directly enter the classroom and provide content knowledge that students patiently received, memorized, and repeated (Freire, 1970). Our teachers had epistemological authority, and they used to ignore students' pre-existing knowledge, aside from accumulating the concepts by teachers in the students assuming their mind as the bank account (Luitel & Taylor, 2005). Thus, my learning journey of mathematics was initiated by depositing teachers' ideas as the silent receiver (Freire, 1970), where the knowledge was a gift bestowed by knowledgeable

persons (teachers) upon students. Moreover, I was learning mathematics to pass examinations of different intervals and to be upgraded to the upper class rather than connecting with day-to-day life.

After completing the formal education at the primary level, standing in the first position, I was admitted to grade six in a secondary school. It was a bit far from my house, and it took me one and a half hours walking to get there. In addition, there were no secondary schools in a convenient place for many students like me. We collected students from the school in grade six from many primary schools. Many students holding ranks were present there. We were in new schools with different values, beliefs, cultures and different techniques of learning. We all were there with some goals and interests for the future. While we were spending our days in the new school, our academic journey was accelerated by teachers of individual subjects without any interdisciplinary and transdisciplinary integration. Each teacher was seriously concerned about our performance in their subject. As I had developed the concept of getting the highest score to stand in the first position, I felt a strong competition. Therefore, my subconscious mind was internally programmed to hold positions rather than seek meaningful mathematics learning. Likewise, my teachers at the new school always encouraged me to compete with my friends by getting decent scores in the terminal and final examinations.

In the view of my teachers, as the result of my consistent hard work, I stood up first and upgraded to grade seven. Since the teachers teaching from grade 6 to grade 8 were almost the same, there was no significant difference in the learning environment of the classes. I still felt challenged to keep my position in the further grades. Most of the teachers insisted on maintaining and improving the grades as the exam of grade 8 was supposed to be more challenging than that of the junior levels- it used to be held

at the regional level, which brought many competitors. Since our learning was accessed via theoretical exams only, the teachers and we did not bother much to seek the application of the concepts taught - concepts of Mathematics, to be specific. It was more of a *chalk-and-talk* approach.

With a similar setup, I upgraded myself to grade 8 without degrading my grades. Although the exam in grade 8 was held at the regional level, the teaching pedagogy was still the traditional one. The teachers encouraged and pressurized indirectly at the same time to bring jaw-dropping scores in the board exam of grade 8. With constant focus and motivation, I also stood up first in the regional exam of grade 8. Although high scores started being filled in my transcripts, it was just on paper; I had not felt a significant sense of personal growth and creativity. I did not feel the engaged learning environment. Mathematics learning was guided by what my teacher used to write on the board, and our only concern used to be copying the work. There was no sense of interaction, cooperation and collaboration from the learning perspective. Instead, some students were interested in copying other students' work to escape the punishment of the teacher's strictness in mathematics. I was lost in figuring out the reason and relation between and among subjects while learning mathematics. My learning experience of mathematics from grade 6 to 8 can be reflected via the following poetic expression:

Mathematics is

Mathematics is a subject with possibility of getting full marks.
For this, I have to -
practice the same problem many times,
follow the method of my teacher,

memorize the related formula,
give more time to recall it ||1||.
Mathematics is a subject of distinguishing the talent students.
For this, I have to -
do hard work,
follow my teachers' guidance,
memorize the contents perfectly,
get the excellent score in the examination||2||.
But Mathematics is a subject having high chance of getting failed if
I do not do hard work,
do not follow my teacher's guidance,
do not memorize all contents,
do not get excellent score in the examination||3||.
I cannot be a talent student if
I do not memorize formulae, definitions and algorithms,
do not follow the rule and technique of maths teacher,
do not accept the knowledge given by teacher,
do not attempt all problems given in the textbook,
do not achieve the highest marks in the examination||4||.

Thus, I made a kind of belief in my mathematics learning from the learning journey of grade six to grade eight that the knowledge is given by teachers such that the knowledge is transmitted from the head of teachers to the students through the *transmission model* of education. As it focuses on teachers-dominated learning environments treating students as the passive absorbers of information, empowering the learners to memorize facts (Nola & Irzik, 2005), we students passively receive the knowledge teachers give.

In grade nine, choosing two among four optional subjects was necessary. For position holders, it was assumed better to take additional mathematics as an optional subject for school administrators and teachers. I followed suit. Among 102 students, hardly nine students agreed to take this subject. Grade nine was assumed very

important from different perspectives: first, it was taken as the foundation of the secondary level. Second, 60% of questions were included from grade nine in the SLC examination. Third, to be involved in the SLC examination, it was compulsory to pass the send-up examination. The question paper pattern of this examination was prepared in the SLC model. Fourth, it was the time to create the base for optional subjects and so on. In grade nine, I was excited about a new set of teachers and a new class on the one hand. On the other hand, there was a kind of fear of the SLC examination, which was taken as an iron gate.

Undoubtedly, my learning was guided by an examination-driven culture of certain hours. Thus, in all subjects, the direct focus of subject teachers was to prepare the students for examination. In a similar pattern as of junior classes, mathematics learning was moved on continuously with the target to complete the course on time and to revise the difficult chapters (such as geometry, word problems of algebra, etc.) to make a stronger base for the SLC examination. However, in additional mathematics, it was a new concept to us, and there was a separation between the concepts of compulsory mathematics and additional mathematics. On the first day, we started with trigonometry, and we all were astonished by listening to the name of Greek letters such as and so on. It was additional pressure on those who were taking additional mathematics as an optional subject to memorize the definitions, formulae, relations, theorems, etc. Probably the learning scenario of additional mathematics is expressed by the following conversation:

Students: Good afternoon, sir! (While the teacher used to enter the classroom, we all students used to greet.)

Teacher: Good afternoon! Good afternoon!! Sit down.

Did you read the definitions and formulae that we discussed yesterday?

Did you complete up to question number 10?

Students: For some moments, we did not speak and just kept looking at the faces of each other.

Teacher: No response? (Furiously!). Okay, I will ask turn by turn.

Hari, Stand up!

Did you read the formulae?

Hari: No, sir! Yesterday, I did not get time to read as I had to support my parents with some urgent work at my home.

Teacher: (More Furious) If you cannot manage time to read additional mathematics, then please do not take it.

Sita, Stand up! Did you read the formulae?

Sita: Yes, sir, but I am still confused a bit.

Teacher: It is just because of the lack of practice.

All of you, if you cannot memorize, then it will be better to drop Additional Mathematics. It is pretty difficult for people who cannot memorize. Never mind, I'll give you one more day to memorize the formulae. Be prepared for tomorrow.

Students: Okay, sir.

Teacher: (Starting new class) Turn your book, Page number 32 and look on the board as well.

Students: Okay, sir.

Teacher: (Solving a problem on the board) Look for the solution on the board. Try to know the process and solve other questions in a similar manner.

Students: (Being attentive and copying the solution) Okay, sir.

Teacher: Did you understand? Re-attempting the solutions is the way to mastering mathematics, there is no shortcut.

Students: Okay, sir.

Teacher: Students, please work hard to excel in the examination. It's quite popular, Ghokante Bidhya Dhawaante Kheeti[18]*. The students who can memorize definitions, theorems, formulae, algorithms, etc. and manage time for repeated practice and revision can do better than others in examinations.*

Students: Okay, sir.

After being upgraded to class 10, the major focus of all the teachers was to make students able to achieve outstanding results. Their primary concern was to complete the course on time and revise accordingly. Their planning was directly associated with high send-up and SLC examination scores. Since mathematics could easily yield full marks to the students, we were encouraged to rote learn formulae, definitions, theorems and solutions for ease in the examination from the initial days of the class.

In the case of additional mathematics, there were many theorems, formulae, trigonometric identities, and problems to memorize for an outstanding exam score. Likewise, in mathematics, particularly in geometry, a lot of practice questions needed to be done in order to solve one unseen theorem asked in the examination. We did model questions accordingly with the exam-oriented guidance of subject teachers. With such preparation, we passed the send-up examination. After that, we were advised by the school to join coaching classes for further practice for the SLC examination and as always, we followed the advice. In 2000 AD, I passed the SLC

[18] It means learning is possible by rote memorization.

examination with the first division. All my teachers and family members praised me. Although we were guided by a traditional approach, getting high marks in the examination made everything seem like a big achievement.

Apart from education, I also had some family responsibilities. As my family depended on agriculture, it was necessary to support the farms during holidays. Also, my everyday duty was to bring water from the tap, which took about 30 minutes from my house in the mornings and evenings. While going in both on the farm and the tap, I used to prepare the list of formulae, definitions and concepts in a paper to recall it on the way and during the resting breaks. Thus, there was no sense of self-directed and contextualized learning inspired by entertainment connecting it with the learning experiences of the students in my learning world (Baek et al., 2011; Park et al., 2012); as a whole, our classrooms used to have minimal interaction, low productivity and high rote learning.

Section II: Throwback to College Life

With mixed feelings of excitement and hesitance, I came to Kathmandu for my formal education at the university level. Having experienced conventional learning all my life, I wanted to pursue further education in an interactive and engaging environment. I probably knew all the concepts, but my mind always strived the search for the application of those concepts. Teachers used to refer to the need for higher-level education to understand the application side of things. With all these in mind, I had high expectations of university-level education to fulfill or reduce the significant gap between concepts and their application. Along with the things I was clear that I wanted to know, I was also looking forward to exploring concepts or facets that I rarely thought existed - like the interrelation between and among disciplines. My mother always said that things always relate to society and culture.

"Can we learn mathematics from a sociocultural perspective? What would it look like?" A series of questions used to pop into my head as I thought of exploring the ways to learn effectively. I was more than excited to explore questions and find answers to them. With many curiosities accompanied by a will to seek answers for them, I enrolled in a renowned institution to study mathematics under the education faculty.

Recalling an incident, the year I joined the college for my I. Ed. degree, our mathematics teacher took 6 months long leave from college. Our syllabus was largely affected as there was none to substitute for him. During the one long winter break, many students took coaching classes to cover up the syllabus. Due to financial issues, I could not take the classes as well; I simply went to my hometown, Dhading and assisted my parents on the farm. After coming back, my friends somewhat already had attained a grasp of the syllabus of mathematics. I felt missed out and humiliated. After six months, when he was back, with no idea about how to prepare for the upcoming examination, I went to talk with my teacher personally. I walked up to him with fear but returned from him with delight. I was surprised by his response. He marked some very important questions in my textbook and advised me to practice and revise only those questions for the examination. I worked accordingly and ended up doing much better than I expected. I was happy. However, when I looked back to that time later, it just felt like everything was a race for a place in the examination. Getting a decent score in the transcripts was what teachers and students ran towards together with all the means available. No doubt I got my marks, but it probably blurred my desire to explore different ways to learn effectively.

Off to the second year, fortunately, none of the teachers took long leaves, and the classes were regular. That year I experienced something unique - about politics in

college. There was an election happening for the Free Student Union (FSU). This disturbed the regular classes. For completing the course on time, teachers used to summarize the lesson rather than making students achieve the focus of the syllabus in detail. Rather than making students involved and interested, teachers were in the race to complete the course on time which they thought was their core responsibility. We gave exams, but the same story was repeated - the race for a place in exams. During this second-year learning, I got the opportunity to learn a subject named “Methods of Teaching Mathematics in Lower Secondary Level” with some pedagogical

Figure 5
Representing Notes Providing Classroom

Source: https://thumbs.dreamstime.com/z/math-teacher-writing-formula-blackboard-20062530.jpg

approaches such as problem-solving, inquiry, discovery, discussion, and so on. Likewise, I learned some learning theories, such as George Polya’s four-step process of problem-solving, Gagne’s learning theory, etc. However, I learned such pedagogical approaches and learning theories; I grabbed such concepts in surficial to pass the examination. Furthermore, in the final year of I. Ed., it was compulsory to teach to the basic level students with about 30 lesson plans. It was taken as the course requirement for 50 full marks. With distorted hopes to explore, I completed the Intermediate level and joined my bachelor’s in the same institution.

After joining my bachelor's, my perspective about mathematics completely turned apart. I had decided to study mathematics to explore its applications but ended up being left in a sea of theorems to memorize in most of the subjects. I remember, in my 9th standard, my teachers told me that mathematics is a subject for students who think critically and are considered the brighter ones over others. Bachelor is where I consciously started questioning all those perspectives regarding mathematics. We had to memorize more than three hundred theorems to attempt about twelve questions in the examination to pass such subjects. That was not an issue until I realized my desire to explore the application sides of mathematics was disappearing amidst hundreds of theorems to memorize, which, as I learned, had no signs of application anywhere. I could never figure out how to copy theorems as such from the board in a class of 125 equally lost classmates would nourish my will to explore applications. However, our curriculum, our examination system and our education process as well seem helpful in empowering such an education system. In addition, in the second year of my Bachelor level, I read the subject "Method of Teaching Mathematics in Secondary Level," as mentioned in the course of study. Under this subject, I learned Piaget's learning theory, Bruner's learning theory, Dienes's learning theory, Gagne's learning theory, Ausubel's learning theory, Van Hiele's learning theory and the social development theory of Vygotsky conceptually instead of practically. Likewise, I learned Bloom's taxonomy of behavioral objectives during my bachelor's level learning. Perhaps, due to our highly structured academic calendar, our teachers could not teach these theories by implementing mathematical concepts. As in I. Ed., it was compulsory to teach the secondary level students at the end of the Bachelor level as the course requirement of 100 marks to complete the bachelor level.

Likewise, after passing my bachelor's degree in 2005 AD, I enrolled in a master's degree program at the same institution with a major in Mathematics. It was the highest level in the institution under university education. Therefore, I hoped to become a well-trained and skilled human resource in one hand. On the other hand, I was curious about learning mathematics at this level regarding the nature of courses, contents, pedagogy, evaluation techniques and so on. But, when I entered the learning journey of master level, I found the same type of curriculum structure, pedagogical practices and evaluation techniques as I was habituated to. Almost all the courses were prepared by including rigid concepts such as theorems, propositions, facts, definitions, etc. To get outstanding achievement, it was compulsory to attempt all questions of the written examination. For this, the major requirement was to memorize all the theoretical concepts. However, some theoretical courses, such as Foundation of Mathematics Education, History of Mathematics Education, Recent Trends in Mathematics Education, and Studies in Mathematics Education, were included under the courses of M. Ed. in empowering and supporting pedagogical improvement. I was learning these subjects from the technique of rote memorization. Thus, I found mathematics learning of this level through rote recall encouraging irrelevant and boring types of the learning environment beyond students' interest (Sparrow, 2008a) and to practical life.

As a structural form of curriculum guided my teachers, there was rarely a chance for interaction between teachers and students. Perhaps, my overall learning experiences from PCL to my master's degree may be reflected by the following monologue:

I was a student of mathematics. As a student of major mathematics, I had a bit different responsibility than other subject students. For me, it was a kind of pressure

to memorize a number of definitions, propositions, facts and theorems to pass the examination with an outstanding score. As I was a position holder and could memorize the nature of courses and the wishes of my teachers, I was a center of attraction for my teachers and friends. In addition, I was familiar with the teachers who were teaching at all levels because I was leading each level. Furthermore, I memorized the definitions, propositions, algorithms and theorems before being taught by the teachers. In the process of rote memorization, I used to be confused while reading many theorems due to the domination of one by another. Once a day, a long theorem with many rigid concepts was taught by taking two periods at the master level. I was involved in teaching in the daytime at a private institution. To memorize it, I used to contribute for roughly two nights. Anyways, I wrote in the examination such that I was able to get outstanding scores in almost all mathematics papers of intermediate, bachelor and master levels.

Together with these multiple means of expressions of my lived experience of mathematics learning, probably the learning process may be guided by behaviorism, where the teachers seemed to present lessons with the pre-determined objective in a '*one-way traffic'* approach and provide some specific ideas for impressing the learners to gain the desired behavior with the use of reinforcement. Moreover, the efforts of subject teachers in my learning journey were devoted to controlling the environment and learners to turn them into learners like them. Perhaps, my teachers were very serious about students' future in the sense of gaining excellent scores. In addition, my learning mathematics seems an instrumental action governed by some technical rules based on the concepts acquired from the content learning of mathematics (Grundy, 1987), i.e., Habermas' technical interest seems closely empowered by the learning scenario. Furthermore, perhaps due to the highly

structured nature of the curriculum, including predetermined learning objectives, predetermined contents, predetermined learning strategies and predetermined evaluation and assessment techniques, my learning journey in mathematics seems more or less guided by technical interest coined by Habermas (Grundy, 1987) rather than practical and emancipatory interest.

Likewise, after completing master-level learning formally in mathematics, I made an image of mathematics as *the subject of compiling theorems, definitions, algorithms and rigid concepts*, which was different from my initial imagination before entering the university level. I made another habit of judging my teachers as those who could write the definitions, propositions, algorithms and theorems on the board without looking at a book. They are talented teachers. Perhaps, my learning practices, course structure, pedagogical approaches, evaluation system and learning context together twisted me toward it. I believed strongly that my teachers were giving knowledge by means of textbooks. There was no chance of *discussion, interaction, collaboration, dialectical environment* and *a design-led approach*, i.e., engaged context to mathematics learning. Probably, the education system was unable to support such an environment. My teachers may be unknown of it due to their long-term practices of a conventional type of rote learning.

However, the common assumption of mathematics learning is students must learn such concepts of mathematics in mathematics classrooms to use the concepts in the later part of life (Clements & Sarama, 2007); in most of the cases, I missed from my practical perspective due to the de-contextualized practices of mathematics learning and its course structure. I agree that instead of revising the pedagogical approaches by examining the existing beliefs and practices (Pant, 2019), encouraging and continuing a teacher-dominated learning environment may be another factor of

de-contextualized learning. In addition, my practice of learning mathematics seems beyond the actual principle of learning how Ariza et al. (2021) argue that the major objectives of teaching and learning mathematics are to enable the learners to gain skills of "speed, and accuracy, developing logical thinking, reasoning power, analytical thinking, critical thinking, the ability of decision-making, scientific attitude, find and verify results, technique of problem-solving, ability to analyze, drawing inferences and generalizing it" (p., 2). Probably, the learning culture that I got from school to university, i.e., up to the master's degree, guided me not to think about such aspects of constructivism regarding learning: *knowledge is constructed, viable* and *adaptation* (Bodner et al., 2001) because I believed blindly to my teachers as the source of knowledge. Likewise, I did not get the kind of learning environment that promotes critical thinking or intellectual inquiry (Wilhite, 2019). As a result, I had a limited understanding of the content and devoted myself to passing examinations with excellent scores based on my teachers' guidelines.

Furthermore, the overall learning journey of mathematics from the beginning of formal education at the school level as well as in higher education at the university level seems guided by predetermined contents and learning objectives where the subject teachers fully controlled students' behavior and learning environment. The whole effort of the education system was to emphasize controlling students' behavior and learning so that the learners can achieve the predetermined goals (Rennert-Ariev, 2005). The main focus was on attaining predetermined objectives rather than the overall development of the learners in the discipline. Probably, my learning journey was impressed by the technically informed curriculum underpinned by Habermas (Grundy, 1987). As the technical interest is "a fundamental interest in controlling the environment through rule-following action based upon empirically grounded laws"

(Grundy, 1987, p.12), my practices on mathematics learning were rooted in predetermined techniques and algorithms rather than multiple ways of learning perspectives. Maybe my teachers were guided by the academic calendar prepared for completing the courses and textbooks mentioned in the curriculum. Therefore, there was no interactive environment in the classroom while teaching and learning mathematics on the one hand. On the other hand, I rarely got the environment to use logic, creativity and self-reflection. In other words, perhaps Habermas's practical interest and emancipatory interest in my mathematics learning were less practiced than my technical interest. However, balancing these three interests is a fundamental requirement in educational reality.

Unlike the approach of STEAM for mathematics, I learned mathematics from the beginning of formal education as a separate discipline. I could not find any linkage between different disciplines and within the concepts of the same discipline (Pant et al., 2020) in my lived learning experience. In addition, I noticed that such a mathematics curriculum largely aligned with the image 'curriculum as subject matter' (Schubert, 1986) is practically used to enable students from the perspective of subject matters isolating from other subjects and other contents. However, students need the integrated knowledge of multiple disciplines in moving daily life smoothly. As a result, it creates limitations in dealing with real-life problems. Thus, I felt a minimal connection to learning various disciplines within a discipline.

Section III: Unforgettable Learning Journey of MPhil

In 2019 A.D., I was admitted to the Master of Philosophy (MPhil.) in STEAM education at Kathmandu University. Although the term "student-centered learning" was not new to me before being involved in the program, I was not much familiar with engaged learning approaches. In my view, my learning practices from the beginning to the master level were rooted in the behaviorist environment, guided by teacher-centered pedagogical practices like one-way traffic instruction (Freire, 1970), rather than enabling pedagogical approaches such as constructivist pedagogy, sociocultural pedagogy, STEAM pedagogy, transformative pedagogy and so on. But, after being a part of the MPhil program at KU, I got the chance to read many articles written by different authors related to different forms of education, enabling pedagogical approaches to empower engaged learning. I got the opportunity of full involvement in the classroom due to the environment of engaged learning by well-experienced and dynamic facilitators. Each class was run smoothly with interaction, collaboration and self-reflection.

Figure 6
Classroom Reflecting My MPhil Learning

Source: https://images.theconversation.com/files/41034/

We were guided by a common purpose of completing a degree with the skills of solving real-world problems. Furthermore, we students were fully engaged with a significant interest in learning in a way that there was no extra burden of memorizing

contents, and there was no vagueness of pedagogies and courses. I felt the journey has been insightful from various perspectives: our teachers were more scaffolders and motivators rather than depositors, different enabling pedagogies were practically used, the seed of STEAM was germinated from the journey, the ideas of many learning theories and their applications were diversified, the creativeness of integration within a discipline and with other disciplines was developed, and so on. Thus, we learned one of the major concepts to solve real-world problems; a person needs the combined knowledge of different disciplines rather than the discipline-wise distinct concept. Therefore, I pursued a change in my deeply rooted values, beliefs, thoughts and feelings regarding mathematics and its learning process from the journey. I conclude that integrated concepts are the fundamental requirement to solve real-world problems. Probably, the following poetic representation has reflected my learning experiences of my MPhil journey:

I felt that …

I felt that I am very relaxed because of
the supportive learning environment.
I felt that I am very confident because of
my teachers' presence and facilitation.
I felt that I am very satisfied because of
sharing my unsatisfaction immediately.

I felt that I am very relaxed because of
getting strong support behind my
learning.
I felt that I am not very worried because
of always having enough support in my
learning.

I felt that I am very lucky because of having enough interactions, collaboration and critical reflection in learning.

I felt that I am very relaxed because of getting the chance of sharing my ideas.

I felt that I am very excited because of feeling the enhancement in learning.

I felt that I am very cheerful because of feeling engaged learning environment.

Section IV: My Role as a Teacher

I have found that the pedagogical approaches which I used in my professional practice have changed significantly during the past seventeen years. During my second-year learning journey, I was involved as a student teacher during my I Ed. to complete course requirements. During this period, I taught the students of grade 6 for 30 days of the lesson plan. Since my goal was to complete a level, I unknowingly focused on preparing lesson plans for each day and implementing them to pass this time rather than engaging students in teaching-learning activities. Later on, after passing I. Ed. I started my journey as a teacher in 2002 AD for the students of grades 6, 7 and 8. In my learning journey of I. Ed., I got surficial knowledge about different pedagogical approaches, such as problem-solving, discussion, discovery, and inquiry, under the course "Methods of Teaching Mathematics in Lower Secondary Level." However, I had no idea about its practical aspect. Since my learning journey was helping me to be a knowledge transmitter, I was teaching my students just to pass the examination with the knowledge transmission process. Moreover, as I learned George Polya's four-step problem-solving approach, I was highly impressed by Polya's problem-solving theory. My overall attempt was to enable my students to solve

problems and achieve outstanding scores in mathematics in the examination. My effort was to make my students perfect in mathematics, enabling them to solve problems wherever and whenever anyone asks rather than its practical perspective. Perhaps, my pedagogical approach was guided by outcomes-based and behaviorist approaches.

Likewise, about 2005 AD, I was sent to teach secondary level to fulfill the course requirement of Bachelor level as a student teacher in a government school for 30 days. During this phase, I taught mathematics with two goals: the first was to complete my degree, and the second was to make a good impact in the minds of students that I was teaching better than the subject teacher. Therefore, I tried to understand the solution to each problem step by step. Finally, I completed my journey as a student teacher delightfully because all students were doing mathematics nicely and giving responses positively. However, my pedagogical approach was conventional, in which I did the solution of each problem, I gave them notes, and my students copied them from the board. There was no active engagement of the students in learning. To copy, it was compulsory for them. Probably, the learning environment was dominated by me due to my learning growing in such an environment.

Later at the end of the year 2005AD, after passing the Bachelor level formally, I started to teach mathematics at the secondary level. As I learned Piaget's learning theory, Bruner's learning theory, Dienes's learning theory, Gagne's learning theory, Ausubel's learning theory, Van Hiele's learning theory and social development theory of Vygotsky conceptually instead of practically; I tried to use particularly the Piaget's learning theory based on developmental psychology. Polya's four steps problem-solving process and Piaget's learning theory became major principles, guiding my teaching journey at the secondary level. However, my major focus was to get awards

by recording history as the interest of school administration and parents by getting many 100s in mathematics in the SLC examination rather than empowering meaningful learning.

Moreover, at the end of the Master's level, again, I was sent as the student teacher to teach the students at the university level to fulfill the course requirement of 50 marks. As a requirement, I taught “Geometry” to the B. Ed. second-year students. I taught them to understand theorems by making rough sketches on the board then I wrote the proof of theorems in simple language. As a result, they all were happy and praised me as a capable teacher. However, there were no pedagogical practices implemented to engage students. They were busy copying notes from the board in one hand. On the other hand, I was busy making them understand the concepts included in theorems and problems rather than engaging them in learning. I felt during this period that I was transmitting knowledge into the mind of students, and they were receiving it.

After formally passing M. Ed. level in mathematics in 2007 AD I joined different higher-level educational institutions to teach mathematics. I felt my pedagogical practices at the college level were distinct from the course of nature. In theory types subjects such as Algebra, Real Analysis, Geometry measure theory, and so on. My effort was to make them understand the theorems, definitions and propositions so that they could memorize them easily for the major focus of preparing for the examination. In computational subjects such as calculus, analytic geometry and so on. My focus was to make them busy in solving problems by doing some sample solutions on the board. However, my focus was to make decent use of students in mathematics rather than developing an environment of engaged learning.

Me as an Almighty

Ask me questions in your confusion

Do all questions, given in the books

Follow the patterns that I have given

Anyhow you have to get high scores||1||

Repeat the same solution many times

Make a time table giving maths more times

Practice many questions from question bank

Anyhow you have to get high scores||2||

Do not sleep more than 6 hours

Read the list of formula preparing in a diary

Keep on study hard each day

Anyhow you have to get high scores||3||

Read the concepts, definitions and theorems

Repeat many times until you remember it

Do not miss comma also in theorems

Anyhow you have to get high scores||4||

In addition, as I had learned some learning theories and pedagogical approaches through different subjects at the master level conceptually, I was interested in implementing them in my professional practice. But the learning culture and existing pedagogical practices in different subjects in these colleges, the nature of courses, the academic calendar and students' habits in learning were not supported in fully implementing engaged learning. I used to imagine how these theories could be used in solving mathematics problems, how to connect theory in mathematics, how to make students busy in learning mathematics rather than copying the solution from the board, how to implement the theorems in practical life, etc. Perhaps, my learning and

workplaces were dominated by behaviorism, where students were focused on solving problems, repeating concepts, reading formulas and definitions, memorizing theorems and so on. Therefore, I used to encourage my students to understand the problems as well as theorems clearly and store them in their minds for the examination. The poetic expression above probably represents the pedagogical approach existing in my practice as the teacher at the time, guided by my experience in the workplace.

My Connection with Autoethnographic Action Inquiry (AEAI)

To fulfill the requirements of 21st-century competencies, it is necessary to revise their educational process. I found that Ariza, Armenteros and Castro (2021) explored a clear explanation of a re-thinking of teaching-learning and a pedagogical shift from teaching to know the concepts to learning concepts to think. In order to revise my professional practices action, research supported me. Next, it has supported me in promoting engaged learning as it is intended to be educational and empowering for all participants.

Likewise, autoethnography (AE) in my research has assisted me in calling upon my own experiences and has undertaken an ethnographic study and application of it based on the cultural context of the educational pedagogy (Lapadat, 2017) in the sense of learning and teaching mathematics. As etymologically, it is derived from the words: auto, ethno and graphy, and these together imply the textual interpretation of the personal experiences gained from their cultural, political, economic and social context of existence (Luitel, 2003); so, to explore my real lived experience in my research I chose autoethnography. I narrated my own stories in my own voice (Keles, 2022) in the empowerment of autoethnography. Also, I found that Sughrua (2019) has explored the reality behind AE's process. In AE, an investigator recalls their experiences by means of narratives and tries to make them meaningful, then connects

them with the stories of others. Moreover, the idea about AE unpacked by Luitel and Dahal (2021) encouraged me to express my happiness and sadness about my experiences through various presentations, including poetic, dialogue, pictures, collages and stories.

Indeed, my research paradigms interpretivism, criticalism and postmodernism together incorporated me to study "the space between self and culture that engages in experiences that cultivate an authentic cycle of action based on reflection, and reflection based on action" (Blackburn, 2000, p.7) representing the methods of critically self-analyzing and understanding by establishing the relationship in social and cultural context (Starr, 2010) in one hand. On the other hand, my interest through my study was to shift in my pedagogical practices as well, i.e., in my professional life as well as in social and environmental factors affecting nature and success of the classroom activities treating as the ongoing process. For this, I chose AEAI as an appropriate means of examining the complex, diverse and messy world of education based on my own experiences.

Furthermore, the lens of autoethnographic action research reflects the understanding from the postmodernist approach in which the effectiveness of existing curricular activities are studied from various perspectives such as the cultural, historical, political and so on (Slattery, 1995). Thus, the use of AEAI in my research has ensured that there should exist revision in both text and context. Its direct impact on my study has occurred in shifting my perspective, my pedagogical practice and my professional life as well. Besides, in shifting my voice as a promoter of engaged learning in my professional life from knowledge provider, analyst, depositor and reporter to critical facilitator, creative participant and even as a learner (Jones, 2006), I have connected with this research design.

In addition, I was paired with autoethnography for the engaging interdisciplinary methods as well as a text both with critical self-reflection (Reed-Danahay, 1997), assuming my own experience as the focal point with the interest of revealing the updated understanding of the existing culture (Acosta et al., 2015). I have tried to uncover and express my emotions, thoughts, and beliefs by remembering, revisiting, and recreating my past experiences (Keles, 2022) by means of autoethnography. As the autoethnographic inquiry empowers to create discourse between the subject and the relevant experiences gained from social, cultural and personal engagement, I used it as a transformative or emancipatory process of knowledge construction. I have explored the transformative value of ethnography through rich analysis of the complexity of my lived experiences and the nature of the ebbs and flows. Next, in the cooperation of action research, I have revised my practices with a broad and deep conceptual understanding of my own practice (Acosta et al., 2015). Thus, I felt the requirement of the autoethnographic action inquiry to interpret my lived experiences from different social, cultural and personal engagement and to improvise my daily practice.

Bridging to the Next Topic

I explored my lived experiences regarding my learning in mathematics as a student of primary to master's level in this chapter. Moreover, I shared my ideas as a professional practitioner of the different levels guiding through rigid behaviorist theory. The major focus was on a teacher-dominated environment rather than empowering an engaged learning environment in both types of practices (i.e., as a student and as a teacher), which seems from the above interpretations under the different sub-headings. Furthermore, the existing pedagogical approaches at the time of learning as well as at the time of teaching both seem unfit to address the demand of

this 21st century. Furthermore, I just felt a rush to complete the course according to the academic calendar in my practice, which I shared above.

While I engaged in the MPhil program at KU, I got a friendly environment in learning with learners' active engagement and was heartily inspired by such kind of learning environment that I explored above. Moreover, I got the opportunity to strengthen my ideas to develop the engaged learning scenario in the mathematics classroom. As a consequence, it brought a kind of transformation to my concept. Therefore, I chose my research topic to empower engaged learning through project-based learning. To enrich investigation and derive meaningful reflection, I have made some ideas. Furthermore, I have initiated to link the concepts of mathematics with other disciplines, i.e., multi-disciplinary concepts as well as interdisciplinary concepts linking the ideas among them through STEAM-based projects. In the upcoming chapter, I have explored 'how I have planned to set mathematics classroom to introduce project-based learning?' in depth. Moreover, I have tried to incorporate some ideas regarding STEAM projects in teaching and learning mathematics in the next chapter.

Chapter Summary

I explained the type of educational environment I got at different levels, from the initial school level to the master's degree and MPhil level, in-depth through this chapter to share the pedagogical practices used in my classroom as a learner. From these overall lived experiences, the behaviorist approach seems to be the dominant practice at all levels except for the learning MPhil level. There was less connection of contents from multiple disciplines and within the discipline. Students rarely get the environment of interaction, discussion, collaboration and sharing of ideas. Moreover, the pedagogical approaches did not encourage the students to be creative and design-

based learning. Mathematics learning was guided by rote memorization of facts and concepts rather than learning in a child-friendly environment. Teachers were teaching mathematics in a way that students were learning not because they wanted to learn but because they wanted decent scores on the examination. Besides, I have talked about how my journey of M. Phil level overcoming the learning stereotype by a multidisciplinary approach has re-shaped my perspective on teaching and learning mathematics.

CHAPTER V

MY PLAN FOR PROJECT-BASED MATHEMATICS LEARNING

Chapter Overview

In the previous chapter, I attempted to capture my learning context as a learner of different levels by means of storied texts based on my lived experience at first. Next, I explored my professional practices as a teacher of mathematics education. With the sharing of learning experiences of different levels, I demonstrated my learning environment, its impact on engaged learning, its effect on achievement and so on. Likewise, I encountered how I connected with engaged learning beyond my conventional practice. I unpacked the turning point of the pedagogical shift, i.e., how I turned in shifting the pedagogical practices to use in teaching mathematics as the transformative teacher.

Based on my critical reflection towards educational pedagogy of early school education to master's degree, I clarified that I have experienced disengaged and decontextualized learning in mathematics in the previous chapter by means of my narratives, poems, pictures, dialogue and monologue as well. Also, I signified the requirement of engaged learning by stating the learning environment of the MPhil level provided by the University. Moreover, I explored rich information regarding deep-seated teacher-centered pedagogical approaches in classroom practices in one context and another total student-centered engaged learning environment. In truly speaking, I was highly inspired by the engaged learning environment that I felt in MPhil learning. Feeling so, I developed the vision of empowering engaged learning in my professional practices.

To develop an interactive and collaborative learning environment promoting engaged learning, I chose project-based learning (PBL) as the means. Besides, I finalized my research issue for empowering engaged learning of mathematics using projects in classroom practices. With this vision, I planned to design STEAM projects (see annex D) and implement them, promoting engaged learning in my classroom practices and addressing my research agendas. In this chapter, I have included the rich ideas regarding this plan together with my assumption in PBL, my efforts in developing this concept, my connection with the STEAM project, its design process, connected disciplines, actors of the plan, assessment and project work and so on. Moreover, this chapter indirectly addresses the research question, 'How did I develop the notion of project-based pedagogy for engaged mathematics learning?'.

My Assumptions on PBL

To promote engaged learning by means of project-based learning, I planned to implement STEAM projects in my research. I made multi-faceted connections between the ideas of more than one discipline in science, technology, engineering, arts and mathematics with the hope that such connections affect the interests, creativity, excitement, understanding, memory and knowledge of the participants on the one hand. On the other hand, it automatically enhances the abilities to apply, create, analyze, design, and evaluate the progression in the students' achievement (Kaldi et al., 2011). Besides, I designed and used STEAM projects (see annex D) in teaching mensuration to build learners' interest in learning with their active engagement.

Next, I was encouraged by the ideas explored by Terada (2018) from the three years research study about the application of PBL in teaching and learning that the students were found more active in learning with more interest and activeness paying

more attention to their peers and teacher. Likewise, the plan was set to encourage students' autonomy, creative investigation and work; to foster collaboration, communication, and a reflection within real-world practices in solving mathematics problems.

In my project, I planned (see annex D) to educate the participants to engage in practical activities and learn through their involvement. For instance, while finding the area of plane figures, students needed to design different shapes of such plane figures, while finding the area of paths, and it was compulsory to construct different paths in the field or compound of their houses. Students benefit from PBL since it encourages them in learning and motivates them towards it (Grant, 2002). My focus while developing STEAM projects was to enable them to deal with real-world problems because such efforts in learning promote them developing a deep understanding and positive vibes in learning mathematics (Serin, 2019). As a result, learning becomes meaningful as well as context-based.

Moreover, as the learners participate in common issues, discuss in groups, attempt group assignments, get involved in designs and present the findings to their teacher as well as peers in PBL, learning happens with full enjoyment. I claimed that using STEAM projects in mathematics is appropriate since it assists them in active engagement in classroom activities (Serin, 2019). Likewise, I believe that the active engagement of the learners in learning is the major issue for the sense of increasing academic performance in mathematics. PBL directly empowers the students' engagement because when students work on projects and understand mathematical concepts, they make the projects relevant to their own lives. Indeed, the mathematics classroom activities guided by PBL engage learners, promoting collaboration in learning and empowering them to find solutions to real-world problems and discuss

discoveries (Uyangor, 2012). Such significant characteristics make remarkable gains in mathematics from overall perspectives. These are my assumptions on project-based learning. Moreover, PBL fosters learners in constructing knowledge in a social context rather than traditional instruction. In planning project-based learning in my research, the projects were considered to provide opportunities for the learners to investigate real-world problems such that these enable them to create new knowledge. Thus, my planning in developing the concept of project-based learning in mathematics was devoted to engaging the students to empower their creativity as well as critical thinking (such as they need to design some plane figures on hard paper, they have to sketch some plane figures on the ground, they have to measure its dimension by different units, they to generalize the concepts, they have to draw a conclusion based on it and so on.) in the learning process.

My Efforts in Promoting Engaged Learning of Mathematics

I found a deeply rooted impact in my learning and professional practices of the learning environment I got from my educational pedagogy. However, my effort through this research was to encourage learners for engaged in learning using STEAM projects in mathematics. Indeed, such pedagogy of mathematics learning inspires students to learn using their skills and knowledge with their full participation. It creates opportunities for deep learning to connect with the context. I was influenced by the idea of Chen and Yang (2019) that the PBL is a well-systematized instructional approach to making busy to students in complex real-world tasks and enabling them to acquire knowledge and life-enhancing skills. Thus, I believe that project-based learning in mathematics classrooms empowers the students to demonstrate their own success and achievement through their own projects.

Next, in the PBL process, students are engaged in teamwork with interaction, cooperation and collaboration to conduct a problem-based independent inquiry and conclude and reflect on the concepts of learning (Li et al., 2022). Also, it forces in identifying authentic problems and doing well-planned activities (Barron & Darling-Hammond, 2008) through designing projects. Therefore, I have designed the STEAM project for classroom application by addressing all these factors of PBL. In addition, I have designed projects that my research participants find meaningful for promoting their academic outgrowth (Larmer & Mergendoller, 2012). The following sub-sections signify my overall plan for designing and implementing my study project.

My Plan, along with STEAM Project

As the theme of PBL, I planned the STEAM projects (see annex D) to empower self-reflected learning in mathematics because PBL assists students in performing self-directed and deep investigations to seek solutions to the issues raised in their daily life (Larmer & Mergendoller, 2012). I planned to foster the participants' active involvement so they could learn at their own pace of learning by exploring the facts and collaborating with their peers (Bell, 2010). In particular, STEAM projects in my plan covered the mensuration chapter of grade IX under compulsory mathematics.

To provide the learning context and environment of knowledge construction and collaboration (Li et al., 2022) through the STEAM project, I have organized activities for students based on it. For instance, to identify and prepare the list of different daily uses of goods representing plane figures (such as triangles, quadrilaterals, rectangles, circles etc.) and measure their boundaries, then note in copy to calculate required values. It means all participants must collect plane shapes from their daily use, design plane shapes and so on. After that, they are required to measure their dimensions to calculate the perimeter and area. Furthermore, it is planned for all

participants to share their efforts by means of project design or work presentations (Serin, 2019) based on their design, measurement and calculation.

As I signified the role of each participant equally in learning mathematics using the STEAM project, I ensured that in the STEAM approach of learning, students are engaged in learning rather than in the role of the audience (Segarra et al., 2018) by establishing interdisciplinary and multidisciplinary relationships between different disciplines. Moreover, I planned for my participants to design plane shapes on hard paper, sketch them on the ground inside the boundary of their homes, and so on. From such activities in learning, I found that it assisted them in an in-depth understanding of problems, innovation of new ideas and cohesive education practice in the classroom. In addition, like the concepts delivered by Li et al. (2022), I ensured from my planning that the application of STEAM projects in classroom learning of mathematics supports increased collaboration, enhances creativity, and even the development of scientific inquiry skills of the participants.

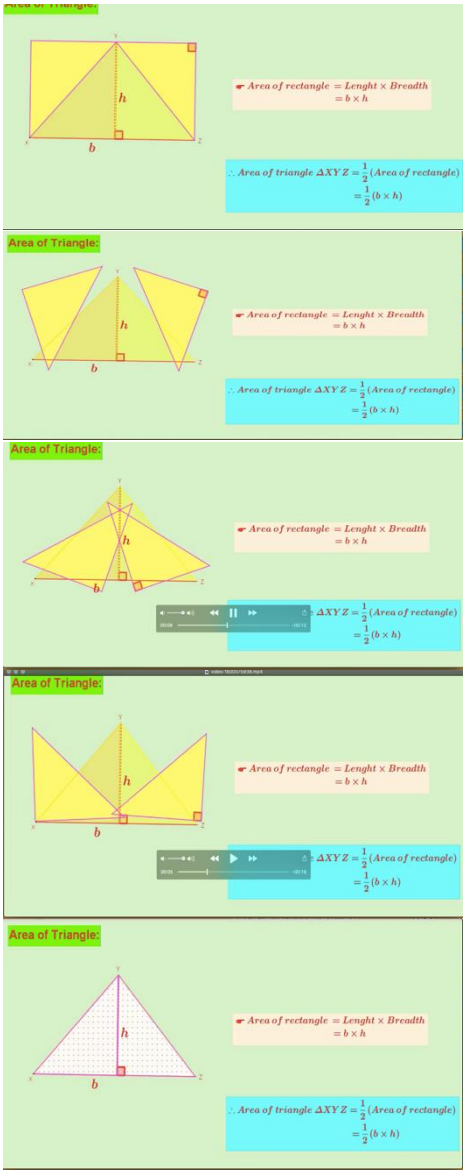
I have planned to organize the project to encourage participants' experimental skills since STEAM education is more experimental and positively influences their learning process (Lu et al., 2021). For instance, participants are needed to collect, draw, design, sketch plan shapes, measure their boundaries, and calculate the perimeter and area. Through the STEAM project, I have emphasized cooperative and collaborative types of inquiry-based problem-solving learning of mathematics using the concept maps technique (Domenici, 2022). They also have to construct knowledge themselves since my research is guided by constructivism also.

I have explored the theme of PBL with the principle *learning by doing* of John Dewey (Bender, 2012) in my STEAM project because my project's nature is what my participants do that is directly connected to their learning. For example, they

have to collect different daily used objects for representing plane shapes to strengthen their understanding of plane figures. They have to connect such ideas in order to solve authentic problems and produce results from the learning (Thomas, 2010). In particular, by cutting hard paper with the design of plane shapes, participants have to learn mathematics in my project means by cutting paper, they preserve the conventional style, and by design, they add a modern concept (Lu et al., 2021). Therefore, I have planned to promote learning through the means of the STEAM project such that the learners feel about the learning context directly in such pedagogy (Zayyinah et al., 2022).

Next, to promote ideas sharing and team efforts in learning, I have made the plan of dividing 30 participants into five groups of 6/6 participants since STEAM aims to empower students to solve problems in innovative and creative ways fostering critical thinking, collaboration and communication with the peers (Quigley & Herro, 2016). Furthermore, I have designed a project for learning mathematics in which participants are required to interact, participate actively, design, collaborate and create new ideas.

Figure 7
Representing Screen Shots of the Videos that I Displayed



The reason behind it was to produce highly qualified and collaborative products from overall perspectives.

However, in my research study, STEAM projects might not compulsorily include the concepts of all disciplines in teaching and learning various concepts of mathematics; I have established the linkage between mathematics and any other one or more disciplines among science, technology, engineering and arts in my projects. Moreover, as

such educational practices enable learners to integrate the concepts and knowledge of science, technology, engineering, art, and mathematics (Zayyinah et al., 2022) in learning mathematics; I have tried to enhance this in my project. For instance, participants have to measure the boundaries of plane shapes by different measurement systems (Science), I have planned to display some videos interpreting structural information of plane figures (Technology), such as the screenshots of videos displaying the area of triangle relating with the area rectangle shown above.

Also, the participant had to design different plane shapes on hard paper. They have to sketch different plane shapes on the ground (Engineering), draw different plane figures (Arts) and note the measured numbers in the diary. They calculated the required values (Mathematics); the project details are in annex D.

Finally, I have planned to make learning more contextual with the help of the STEAM project as the PBL empowers context-based learning through complex activities such as giving students the freedom to interact

Fig-VII: Representing the screen shots of video in the processing of

learning activities; carry out collaborative projects, and (Adriyawati et al., 2020) in their local context. For instance, participants of my research have to collect daily used objects related to plane shapes, they have to sketch different plane shapes in their local premises, and then they have to measure the

boundaries into different units such as local units (hat, bitta,..) as well as in standard units (centimeter, fit, meter,…). Thus, I have planned my STEAM project (see annex D) for the purpose of holistic development of the participants so that they can solve their real-life problems. Probably, the overall project plan of my research from the participants' perspective is reflected by the following poetic expression:

Therefore!

We have common issues.
Therefore,
We involve together.
We feel together.
We do together ||1||.

We have to create our new world
Therefore,
We plan together.
We design together.
We discover together ||2||.

We have to connect mathematics in our life.
Therefore,
We share together.
We create together.
We solve the problems together ||3||.

We have to establish the interdisciplinary and transdisciplinary connection in mathematics.
Therefore,
We think together.
We work together.
We find together ||4||.

Main Actors and Contexts of My STEAM Project

Due to the pandemic situation of COVID-19, I planned to carry out my project implementation virtually. Therefore, while planning and designing the STEAM project, I have also considered this factor with the main purpose of promoting engaged learning of my participants with the vision of developing critical thinking, collaboration, problem-solving skills, creativity and communication (Bowman, 2010) in mathematics learning. In addition, I have planned to enrich the participants' understanding by connecting the concepts of different disciplines, interacting over the problems, and sketching ways of practicing in real-life situations rather than isolating the discipline (Lu et al., 2021). For instance, while solving the problem related to the perimeter and area of plane figures, I have linked the concept with STEAM disciplines (see annex D). Thus, I have envisaged my research project as a holistic approach to learning that connects the individual disciplines to develop a learning scenario in which the learning becomes integrated, meaningful and relevant to the learners' lifestyle (Smith & Karr-Kidwell, 2000). From this signification, it is clear that my research participants are my study's main actors.

Moreover, I have planned the STEAM project of my research by integrating the knowledge of more disciplines to assist the participants in developing, synthesizing and applying knowledge. Also, through the project, I have ensured to promote higher order learning skills in learners, empowering them to use the concepts in real-world problems and perform rich tasks (Treacy & O'Donoghue, 2014). Besides, the main focus of the integration was to make it easy to learn mathematics to my participants in the traditional content areas (Cardella et al., 2014) in one hand. On the other hand, to support my participants to create new knowledge by integrating the concepts of STEAM disciplines (Ostler, 2012) so that they could solve real-world

problems and recall and enhance the transformation of ideas (Fitzallen, 2015). For instance, all participants must also perform their duty connecting with the lesson. However, participants should be actively engaged in learning mathematics from the nature of PBL that I designed in my STEAM project. From these discussions, it is clear that participants were the major focus.

Next, I have planned myself as the facilitator for providing sufficient information regarding the project application to my participants. For example, I have planned to display videos of plane figures' structures to enhance the concepts of plane figures. I have planned activities to be performed (see annex D). Since I have to be engaged with the participants in my research as the scaffolder, I am another actor in this project implementation.

Furthermore, the project is needed to implement by the school students of grade IX virtually. Therefore, school and virtual classrooms are contexts of the project implementation.

Assessment and Evaluation

I have planned for the STEAM project to fulfill my research purpose in such a way that it promotes problem-solving and inquiry-based learning skills to integrate multiple disciplines and allows participants for finding the solution in active involvement (Lu et al., 2021). For this, my participants have to assess possible natures (such as by collecting the plane-shaped objects, sketching, Drawing, designing and so on.) based on the concepts discussed. Moreover, participants must complete each concept (such as perimeter and area of triangles, perimeter and area of a rectangle and so on.), according to my plan, to perform an assignment related to the concepts. As STEAM learning encourages students to develop different skills by engaging them in learning activities and enabling them to implement knowledge in solving problems

(Zayyinah et al., 2022), my participants have to perform their experimental activities. They have to fill out a worksheet based on it, like the lengths of boundaries of the plane shapes and calculations of required values in different measurement (local and standard) units. Finally, they have to conclude with the verification of the formula approach.

Besides, they have to interact and collaborate virtually about the problem-solving, and a member of each group among six is needed to share and present the conclusion in the virtual classroom. The group members should be different while performing different concepts, i.e., all members are required to perform turn by turn in different concepts. The final evaluation has been made based on the continuous observations of the activities, performances, interest towards learning, active participation in learning, engagement in teamwork, enrollment in the collaborative work, submission of assignments, problem-solving skills and creativity of the participants, such as the participants who have submitted their assignment, project work (see annex E) based on the requirements as given in project (see annex F) is evaluated as the candidate of success.

Bridging to the Next Topic

As my research topic is guided by the concept of project-based learning in mathematics, I made some plans for enriching project-based learning through the design of some STEAM projects in teaching mensuration chapters under mathematics to grade IX students. Indeed, the design of STEAM projects and their implementation come simultaneously. Therefore, in this chapter, I have mentioned my overall plan for empowering project-based learning. As the demand of my research, in the next topic, I have mentioned how I carried out my projects to conclude.

Chapter Summary

I presented what I did to empower project-based learning in mathematics as the purpose of my research study. In particular, my overall planning in designing STEAM projects while teaching mensuration under the mathematics of grade IX was included. Indeed, teaching mathematics by establishing relationships between any subject within itself or between more subjects becomes more effective than teaching it as a separate discipline. Thus, to empower such concepts in mathematics teaching, I tried to make a tiny effort through this chapter by sharing the ideas and planning of using STEAM projects in mathematics teaching, which is guided by my research objectives.

CHAPTER VI

WORKING WITH THE STUDENTS IN THE PROJECT-BASED LEARNING

Chapter Overview

In the previous chapter, I explored my plan to design the STEAM project for the empowerment of engaged learning in mathematics in one hand. On the other, I mentioned my plan for implementation of the project in classroom practices. By incorporating these ideas, in this chapter, I have tried to present the implementation scenario of the project. Furthermore, I have tried to include my students' perceptions toward the project in learning mathematics, their active involvement, cooperation and collaboration in learning, their creativity and excitement during learning, and their level of understanding through the project. In other words, I have indirectly tried to answer my research question "How is my implementation of project-based pedagogy in learning mathematics?" under this chapter.

Contextualizing Mathematics through Implementation of the Project

For my study, I designed the STEAM project based on my plan by intermingling the concepts of different disciplines among science, technology, engineering, arts and mathematics in teaching and learning mathematics. The project was designed for 30 days, i.e., November 2020, for classroom practices to the students of grade IX in teaching the concept of perimeter and area of plane figures under the mensuration chapter of compulsory mathematics. The project's motto was to engage learners so that they learn mathematics with the connection between theory and practice on the one hand. On the other hand, it was planned to make able to apply their ideas in dealing with real-life issues (Bender, 2012). Moreover, the first aim of the project to the students was to familiarize them with the plane figures and their

dimensions through their investigation of the daily life goods and artifacts existing in their homes. In addition, they were encouraged to strengthen the concepts regarding plane figures by means of drawing, designing and using visual aids through GeoGebra for the structural form of such plane figures. Secondly, they were empowered to identify the length of the dimensions of such plane objects using different measurement tools and systems.

Figure 8
Facilitating Participants Virtually

Here, I have tried to reflect the classroom scenario through five representative students with their pseudo names. Probably, the activities of these participants clearly reflect the learning procedure and their active involvement in the following topic.

Students' Enrollment in Learning

The participants of my inquiry engaged in project-based learning guided by three principles of constructivism: learning is contextual, active involvement of the learners and the achievement of goals (Kokotsaki et al., 2016)). The pre-assumption in the learning was that students need to get the chance to be involved in the knowledge construction procedures themselves by solving real-world problems by raising questions, designing and creating through investigations, gathering, sharing, analyzing and interpreting the ideas, then generating themes for the actual findings. For this, students were involved in the overall learning process based on four phases: recognizing the context, empowerment of design thinking and STEAM pedagogy, collaboration and ideas sharing in learning, and active group efforts to achieve a common goal, i.e., learning outcomes.

Phase-I: Recognizing the Context

In the first three days of November 2020, students were allowed to build clear concepts about plane figures and concepts regarding different types of calculations based on the measurements of dimensions of the plane figures. During these classes, some prerequisites regarding the conceptual understanding of plane shapes were discussed by means of posters, drawings, GeoGebra drawings, etc. The main goal of the lesson needed to be achieved, as mentioned in the curriculum, was interpreted among them such that their activities and engagement helped to fulfill the common goal. With this knowledge regarding the topic and its major goal, all students, Krishna, Radhika, Muna, Gopi and Saron, found to organize a virtual meeting regarding identifying the objects having plane shapes at their home directly or indirectly used in their daily lives. Moreover, they were engaged in learning by paying worth to learning (Serin, 2019), i.e., they enriched the concepts of the plane figures through many objects such as photo frames, artifacts, plates, bowls, cutting boards, dining tables, TV screens, mirrors, etc.

In the fourth day's class, I penetrated some questions in the class as the conversation given below:

Me: Can you tell me some examples of plane shapes among the daily used objects at your home with corresponding shapes?

Krishna: Yes, sir; the dining table is circular, the windows a rectangular shape, the photo frame is a square shape, artifacts at his house in triangular and trapezium shapes and so on.

Radhika: Yes, sir. I want to add some plane shapes such as nanglo (a flat round woven tray made up of bamboo), plates, water tank lids, etc. are circular, mirrors in rectangular shapes, some artifacts on the floor are in the form of

squares, some are in the form of quadrilaterals, and some of them are in the form of kites.

Muna: Me too, sir. TV screens, laptop screens, cupboard faces, etc., are rectangular shapes, and tapari is circular.

Gopi and Saron: Yes sir. We found the same types of objects as our friends mentioned.

Me: What about the dimensions (boundary lines) of these boundaries and their measurement? Can you measure it?

All students (At a time): Yes, sir. The lines that enclose these shapes are boundary lines. We can measure it using a scale, thread, measurement tape, etc.

Probably, the above conversation reflects the conceptual understanding of plane figures. Likewise, empowering constructivist and sociocultural theories (Serin, 2019), they actively identified the plane shapes relating to these concepts, such as pooja ko thali, tapari, nanglo, home kunda, etc., regarding their culture as well.

Phase II: Empowerment of Design Thinking and STEAM Pedagogy

In the project-based environment, students are excited to learn mathematics with the development of creative and deep thinking to enrich an in-depth understanding of the mathematical concepts beyond conventional classroom practices that empower algorithmic patterns of solutions by recalling the concepts (Kokotsaki et al., 2016). Enhancing the same types of efforts, my participants were encouraged to draw and design the plane shapes by different means after identifying the objects representing various plane shapes.

For instance, Krishna made three types of triangles: *equilateral, isosceles* and *scalene* triangles, with the help of a scissor and hard paper. Likewise, he designed additional plane shapes such as *quadrilateral, parallelogram, rhombus, rectangle,*

trapezium and *kite* from hard paper. Radhika drew the figures of such shapes on paper, making them colorful in an attractive way on her computer and paper. Likewise, Muna and Gopi designed such shapes inside the compound of their houses using white dust. Moreover, they designed the shapes of three types of paths: *inner paths, outer paths* and *cross paths* on the floor, strengthening the concepts of plane shapes. Similarly, Saron demonstrated different plane shapes virtually through structural perspective using GeoGebra. Such individual creations were shared in the group because the solutions to authentic problems were derived based on the group efforts (Guo et al., 2020), in which my existence was as a facilitator for providing feedback and support for learners to assist their learning process.

In addition, the learning process was enriched by the project-based learning related to STEAM curriculum design, such as the application of arts, design thinking, technology and so on., were playing a pivotal role in their interpretation. They tried to interpret the same concept in multiple genres. By observing their activities directly or indirectly, I felt that they contribute to developing the concepts of STEAM pedagogy in the mathematics classroom with full excitement (Kokotsaki et al., 2016). Actually, their learning was considered to be a particular type of inquiry-based learning where the context of learning is provided through authentic questions and problems within real-world practices.

Phase-III: Collaboration and Ideas Sharing in Learning

Through projects in learning mathematics, my participants believed that concepts in mathematics are constructed through social interactions, collaboration and idea sharing (Kokotsaki et al., 2016). Therefore, they shared their understanding and feelings with each other in the group. It seems they are devoted to achieving a shared

goal through the project with the help of interdisciplinary and transdisciplinary relations.

Since all participants were contributing to the shared outcomes with active reflection and conscious engagement rather than passive experiences, it was observed that an experiential or collaborative approach empowers the learning process. After sharing the common goal of involvement in the project among the peer, it strengthens the concepts of designing and creating their projects to result in deep engagement of the learners (Wurdinger et al., 2007). In addition, students were encouraged in the learning process to be self-reliant through goal-setting, planning and organization. For this, they developed collaborative team efforts and became internally interested in learning with collaboration, reflection, redrafting, and presentations of their efforts in the group. I felt that my students were sharing by heart about their efforts and outcomes to each other with full enjoyment in one hand. On the other hand, they searched for different relationships between the various plane figures in team efforts.

For instance, Krishna shared ideas regarding the structural aspect of different plane shapes such as *triangle, quadrilateral, parallelogram, rhombus, rectangle, trapezium, kite* and so on. from the designing perspectives. With his sharing, some of the friends expressed their additional views, such as

Muna: Oh! Very interesting, Krishna. Can we show the relationship between any two such plane shapes, for example, triangle and parallelogram, from such a design?

Likewise, Radhika shared her works from a drawing perspective with its net diagrams in two ways: drawing paper by pencil as well as through computer.

Muna and Gopi shared their ideas regarding plane shapes as well as three types of paths from the perspective of design thinking regarding what they have designed in the premises of their house. By enjoying their works, Radhika presented her idea:

Radhika: Oh! Very interesting. We can use the concept of rectangles in calculating the area of paths.

Similarly, other friends were expressing and concluding the ideas regarding these presentations. Moreover, Saron presented his work in a bit different way than the others. He linked technology to strengthen the concepts of plane shapes by preparing videos and figure animations providing different measures through GeoGebra. All of them were taking full enjoyment from his work. They got the chance to learn different structural relationships from his effort. Such sharing habits of students helped them to strengthen their conceptual understanding of the lesson in multiple ways by ensuring no gap in theory and its practice (Veselov et al., 2019). Thus, the students were engaged in learning actively individually with team spirit and combined effort to achieve the shared goal.

Phase-IV: Group Efforts for Common Goal (Learning Outcomes)

After completion of the conceptual understanding of the plane figures from various aspects taking more than two weeks time duration, my students reached near to the ultimate step of learning, i.e., they were ready for the measuring dimensions themselves using measurement tools such as measurement tape, thread, meter scale, short scale, etc. likewise, for measuring the plane shapes made in the ground, they used local units such as Hat, bitta etc. in order to empower the contextual learning according to their local measurement. After measuring the sides (and the vertical height if required), they calculated the area and perimeter of the plane figures and paths. For this, firstly, they calculated it from the structural perspective, and then

secondly, they checked the consistency of the solution by using a conventional approach, i.e., using a formula. For instance, I have unpacked the activities of some particular participants with their pseudo names. First, I have taken Krishna's activities as below:

I selected a flat cardboard which signified a rectangle. I measured its length and breadth, then I found the sum of all sides for the perimeter and multiplied these dimensions to find the area at first. Then, I used lb for the area and 2(l + b) for the perimeter. From both techniques, I got the same conclusion.

With the above conclusion, I generalized the concept of the area of a rectangle, taking a right-angled triangle as half of the rectangle. For this, I measured the lengths of all sides of the three types of triangles that I made from hard paper. Also, I measured the vertical height from the vertex to the base of each triangle. Then I found half of the product of the base and the vertical height for the area of each triangle, and the sum of all sides for each perimeter.

For the determination of the accuracy of the calculation, I used different formulas, such as for isosceles triangle, and he used for area and for perimeter, where a denotes the length of equal sides and b denotes the base. Similarly, for a scalene triangle, I used area and perimeter, assuming a, b and c as the lengths of the sides of the triangle.

Likewise, I used the area and the perimeter of the equilateral triangle by assuming a as the length of each side of the triangle. From both calculations, I got the same conclusion. From these activities, what I did regarding the perimeter and area of triangles, I felt enjoy in learning. Next, without feeling any burden, I can also solve the related problem given in the textbook.

Next, I have presented Radhika's activities as follows:

I took the top of my tea table as my object. When I measured its dimensions, I noticed the length and breadth were equal, so it was a square. To find the perimeter, I multiplied the length by four, and for the area of this object, I squared the length. To check the uniformity in the solution, I used area and perimeter. Again, I measured the lengths of diagonals and got the same in a square case. Then I calculated assuming d as the length of the diagonal for the area. I got the same conclusion from both cases.

Likewise, after getting the uniformity in the result in the case of a square, I measured the lengths of all sides of a parallelogram and the length of perpendiculars between two pairs of opposite sides. Then I calculated the product of the length of any side with the length of the perpendicular drawn to the side from the point of the opposite side for the area and the sum of all sides for the perimeter. To check the uniformity of the calculation, I used area and perimeter assuming as the length of a non-base side, b as the length of the base side and h as the length of the perpendicular drawn to the base side.

Also, I measured the length of a side of a rhombus and the length of the perpendicular drawn to the side from the point of the opposite side. I used for area and perimeter of the rhombus by assuming the length of each side a. I also measured the lengths of the two diagonals of the rhombus, then I divided the product of the lengths of these diagonals by 2 and got the same value equal to the area. From this calculation, I got another way of calculating the area of a rhombus. I also did all these activities with full excitement. I did it myself. But I did not feel any boring environment at the time of doing these activities. I felt too easy in learning because I did it experimentally and using formulae as well. As a result, I learned the concepts easily.

For calculating the area and perimeter of a trapezium, I have unpacked the activities of Muna given below:

I measured the lengths of all sides and also the length of the perpendicular between two parallel sides. After measuring it, I divided the trapezium into two triangles, calculated the area of the two triangles and added them to find the area. Likewise, I added the length of all sides to calculate the perimeter of the trapezium. I checked the uniformity of the area by using a formula assuming the parallel sides and h as the distance between them. From both, I got the same outcome. Similarly, to calculate the area and perimeter of a kite, I measured the length of all sides and the lengths of both diagonals. After this, I calculated the area of a triangle made by the long diagonal of the kite and multiplied it by 2 to get the total area of the kite. For the perimeter, I added the lengths of all sides. To check the consistency of the area calculation, I used a formula. I got the same result from both. Like other friends, I did all these activities with full enjoyment and learned the concepts easily from this technique.

Likewise, Gopi's activities are presented below:

I took a quadrilateral formed from hard paper, measured the sides of all edges, measured a diagonal, measured the lengths of perpendiculars drawn from the remaining opposite vertices to the diagonal, and recorded it. After this, I calculated the areas of two triangles and added them. Also, I calculated the area using a conventional approach through a formula assuming that as a diagonal and as the lengths of perpendiculars drawn from the remaining vertices to the diagonal. I got the same conclusion from both cases.

Similarly, I measured the length and breadth of the rectangular shapes that I designed inside the compound of my house by using local units (Hat, bitta) as well as

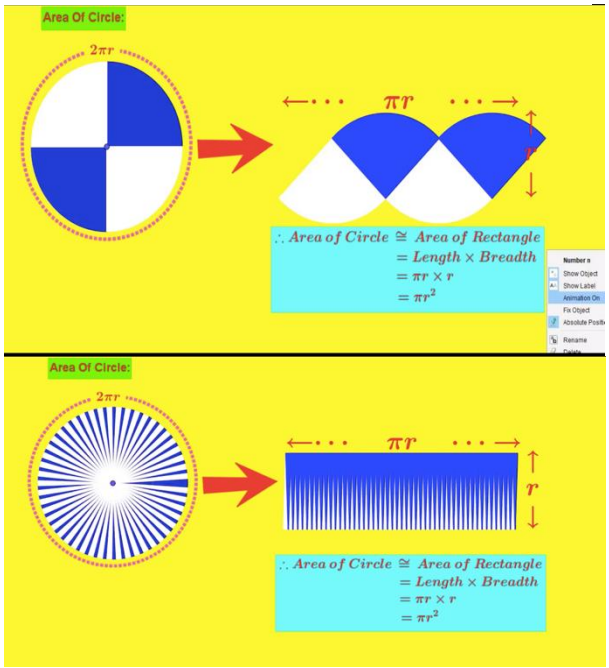
measurement tape in order to calculate the area of paths (inner path, outer path and cross paths). Then I calculated the area of the rectangular shapes, including path and excluding path and their difference in the standard units of measurement and local measurement system. I searched the relationship between such different measurement systems and shared it in a group. To check the uniformity of the solution, he used outer path, inner path and cross paths, assuming l as the length and b as the breadth of the rectangular ground and d as the uniform width of the paths in each case. I got from both relations the same answer. I also learned the concept without the rote memorization technique.

Also, Saron's activities are presented here:

I demonstrated the relationship between the area of a triangle and a rectangle virtually using GeoGebra. I clarified that the area of the triangle is half of the area of the rectangle by making the same base taking the vertex from a point of the opposite side of the base. Likewise, I demonstrated how to calculate a circle's area by reducing it in the rectangle virtually through GeoGebra. I used the product of the rectangle's length and breadth to calculate the circle's area. For the consistency of the result, it was checked by using. From both cases, I got the same conclusion. Finally, I found that project-based learning is the best for learning mathematics.

Figure 9

Screen Shots of Saron's Presentation



However, I mentioned the efforts of students individually in learning mathematics according to the project; these students were taken as the representative from the class, and they divided their duties their collaboration, interaction and group discussion. Students were instructed to measure each dimension thrice and then take the average to minimize measurement errors. It was clear that their practice in learning incorporated the project activity with the design of a particular project based on the sharing of the discoveries (Veselov et al., 2019). They enjoyed the learning because they were allowed to collaborate in a team and construct the concepts in combined efforts (Whatley, 2012). Probably the engagement of the learners in the learning can be reflected by the following poetic expression:

We need freedom!

Dear teachers, encourage us
to play with the content in nature
to search in our context
to do in our environment
because we need freedom

Dear teachers, give us chance
to interact among us
to show what can we do
to explore our identity
because we need freedom

Dear teachers, empower us

to speak from our heart

to link the context and the content

to share our feelings and ideas

because we need freedom

Dear teachers, guide us

to exist with our own identity

to realize what we can and cannot do

to enrich our ideas in content

because we need freedom

Dear teachers, treat us

as the human beings

as the creators

as the persons of potentiality

because we need freedom

Indeed, as expressed through the above poem, students were interested in learning with a free mind. They hoped the teachers' role as facilitators rather than as depositors of the content. They required well-planned learning that fosters learners in productive skills and concepts instead of providing a load of content and a bundle of certificates by passing the written examinations with excellent scores. Students who have a suitable learning environment can construct knowledge through active involvement, interaction, collaboration, and group support. Actually, I believe that my students need student-centered educational pedagogy, which empowers learners'

collaboration to promote their questioning behavior and enable them to acquire high-order sustainability skills under the teachers' facilitation (Ferrero et al., 2021). They can also be empowered for engaged learning from such a learning environment.

Challenges Occurred in Implementing the STEAM Project

However, I have shared my own ideas with the help of many authors' ideas regarding only the benefits of STEAM project-based learning mathematics; there are some major challenges as well. Designing STEAM projects is challenging for teachers as it requires in-depth knowledge of more disciplines. Also, I felt that the lack of the concept of meaningful interdisciplinary integration (Li et al., 2022) creates confusion among teachers and learners. In our context, the teachers are appointed based on subject expertise. As a result, they become experts in a single subject only and unable to achieve a rich conceptual understanding of multiple disciplines expected by STEAM education (Li et al., 2022). From this, we can easily guess that there is a lack of qualified teachers knowing STEAM disciplines. From the expert of the specific subject only, the multidisciplinary and interdisciplinary integrations cannot be effective. Even, I experienced such kind of confusion at the beginning of generating research issues and in my planning.

Next, education planning and decontextualized and structured curriculum practice become other challenges in our context for implementing the STEAM project. The compulsion to complete the syllabus according to the academic calendar before each terminal examination is a big issue. Next, I felt that it takes more time to conduct teaching-learning activities by designing STEAM projects (Zayyinah et al., 2022). In our context, following the national-level curriculum framework and academic calendar is compulsory to promote students in the upper classes. In addition, I found it difficult to convince students and parents regarding its

implementation in teaching and learning at the initial phases of implementation due to the lack of awareness. Yet, parents were raising questions about the timely completion of the courses. However, after the project's implementation, they were satisfied by feeling their child's conceptual understanding and activeness.

Likewise, individual differences appear in the design and implementation of STEAM projects (Li et al., 2022), i.e., its design and implementation depend on the idea and knowledge of the individual. Therefore, its sustainability is always at risk. Moreover, geographical diversity, lack of uniformity in development, lack of appropriate planning in the education system, lack of well-managed teachers' training programs and lack of multidisciplinary knowledge in teachers are also remarkable challenges in our context. Therefore, applying STEAM projects in classroom practice does not seem easy despite its many positive impacts on educational pedagogy.

Furthermore, researchers raise some issues about the design and application of STEAM projects in our context for certain purposes after completion of their purposes, i.e., with the end of the research, the project end. In doing so, its implementation is becoming meaningless. Thus, I arrived at the understanding by the implementation that the design and application of STEAM projects in day-to-day classroom practices is the best method of educating students in this 21st-century education. However, it is a challenging work from different perspectives, such as conceptual, contextual and empirical in our context.

Bridging to the Next Chapter

From the role bearing by the students in learning mathematics, I believe that PBL manages the complete enjoyment of the students' autonomy and initiative in learning elsewhere. The role of students in strengthening their conceptual understanding of the content from different perspectives and their attempts to solve

problems was admirable. Indeed, all students were compelled to perform at least one role regarding their learning, as I mentioned in this chapter. From this, it was observable that PBL efforts in the fusion of many disciplinary concepts (Liu et al., 2019). Moreover, I explained in this chapter that my students were learning mathematics by means of exploring such that it enhances learners' ability to connect the multi-disciplinary concepts in solving the issues of their daily life as well. This is clearly explored from the different roles of learners from different perspectives but targeting the same goal in the chapter. In addition, in the chapter, it is visible that PBL empowers the collaborative spirit in learning (Liu et al., 2019) since the students learn through team efforts by undertaking group activities and performing in collaboration. In the next chapter, the overall reflections based on the use of PBL in the mathematics classroom are explored from different perspectives.

Moreover, the conclusions drawn from the shift of pedagogical practices, i.e., from conventional practice to modern (project-based) practice, students' views, interests and feelings towards this new practice, its impact on the overall learning outcomes etc., are included as matters of discussion in the next chapter.

Chapter Summary

In this chapter, I have tried to reflect on the learning scenario through the distribution of duties, attempts, presentations, sharing, discussion and final works of five representatives of the class nine students. Furthermore, the chapter focused on how the mathematics classes were run according to the planned project. How were the contents interlinked? How were the connections established between different disciplines? How did the use of ICT empower learning mathematics? How can the concept of designing a vision be implemented? And how it can enrich the concepts etc., were addressed. To foster the concepts of project-based learning, what attempts

were made from the students' side and teacher's side in the sense of implementing the STEAM project were included in the chapter.

CHAPTER VII

REFLECTING ON THE OUTCOMES OF MY INQUIRY

Chapter Overview

In the previous chapter, I explored the implementation of the STEAM projects in my research. This chapter has reflected on the experiences of my research participants based on their activities, their engagement in learning, their interactions, their collaboration and critical reflection on mathematics learning. Next, I have unpacked my own reflections based on my observations, interviews, participants' responses and submitting assignments, their performances, etc.

Moreover, I have included the overall reflections generated from my plan for engaged learning, selection of projects, nature of projects, design of STEAM projects and their implementation in classroom practices in this chapter.

My Participant's Reflections

With the designing and implementation of the STEAM projects in learning mathematics, I became very close with my participants by observing their activities, interest, creativity, interaction and efforts in learning. To determine the effectiveness of projects, I tried to understand my participants from different perspectives. I observed their activities continuously during the research. I provided them with clear guidelines for their confusion. However, I did not teach them in what way I used to teach them previously. I took unstructured interviews frequently to recognize their perceptions and feeling about this learning journey. I noted that all in my diary, memos and even in a logbook. Also, I developed a google form by including five open questions, and I handed them over to them to fill in at the end of each concept

that they were learning. It was done to get the exact views and experiences of all participants.

Based on my effort regarding the application of STEAM projects in classroom practice to determine the real experiences of my research participants, I have presented here a piece of dialogue between the participants about project-based learning.

Rishav: Hi, friends! I am very impressed by this new technique of learning mathematics as we are doing all activities ourselves. What about this method of learning mathematics, in your view?

Rijan: I am feeling so excited to learn; however, it is taking a long time.

Pratima: Me too! We are learning the concepts without rote memorization. I am learning mathematics indirectly by involving in projects.

Preeti: Yes, friends! Really, I am enjoying learning mathematics as the teacher is guiding us to perform ourselves by giving clear directions.

Rishav: Another interesting part is you know all your friends? Our teacher interprets the concepts by designing different models, demonstrating in PowerPoint, by videos, connecting to the daily used materials and so on. This type of connection in mathematics, I felt very interesting and essential as well.

Rijan: Absolutely, friends! I learned the concepts of dimensions, perimeter, and area of the different plane figures by measuring practically myself what is available at my home, such as the dining table, the boundary of plates, and glasses, the boundary of windows, photo frames and so on.

Pratima: Yes! I agreed with you guys. I cut the hard sheet of paper, and I formed different shapes of plane figures from it in order to calculate its perimeter and area. From this type of learning, I am feeling easy to learn mathematics.

Preeti: Of course! If all contents of mathematics are taught by this technique, it will be better for us.

Rishav: Did you check your calculations by putting the corresponding lengths in the corresponding formulae? What did you find? In my case, I checked it and found the same in both techniques: experimentally and conventionally, i.e., putting in formulae.

Rijan: Yes! I also checked it and found the same. Besides, I felt it easy to remember corresponding formulae by its practical calculations.

Pratima: I felt same Rijan. Let us request our teacher to teach all chapters in the same way. What about your friends?

Preeti: No doubt, I agreed on it. But is it possible to complete the course on time using this technique? Anyway, let's talk with our teacher about it.

All: Ok! (in the same sound).

Indeed, the above conversation between the participants shows that learning mathematics through the project-based pedagogy was effective because they learned mathematics by connecting it with their daily life on the one hand. On the other hand, the concept of mathematics was linked with multiple subjects, including science, arts, technology and engineering. Also, the other most remarkable point was, they did practically what they learnt. As a result, they were assisted in promoting interactions, collaboration and critical reflection in learning mathematics. Next, each individual was equally engaged in learning with their individual responsibility, so it reproduced their creativity, excitement and fun in learning. They are interested to collect the related daily used objects, and they are excited about designing different plane shapes. They enjoyed drawing, and they were encouraged to measure the boundaries by different units and calculate related values. They found only confused

about whether the course will be completed or not by this technique as it requires a bit more time.

In addition, from the regular observations and understandings of participants' activities, engagement, excitement, performances and views towards mathematics learning using project-based pedagogy; they are found to be more excited in learning mathematics. I also took the views of some representative participants' regarding this practice, such as a male participant, A replied, "*I felt very easy and interesting while using the STEAM project in learning mathematics because our subject teacher only facilitated the learning. Before using such a technique, he used to do derivations of formula, he used to give a list of formulae, and he used to solve a maximum number of problems himself. As a result, it was necessary to memorize the solution. But by applying this technique, we solved all problems ourselves under collaboration. Another interesting part of learning that I felt is that in the previous/non-project-based pedagogy, we learned mathematics as a separate discipline. Just we solved the problems based on the guidelines given in textbooks to pass the examinations. But, in this new technique of learning, I tried to relate the concepts to the other disciplines as well. As a result, it boosted our learning effectively. Furthermore, according to the initial description of our teacher, I cut the hard paper to form the different shapes of plane figures such as triangles, quadrilaterals, parallelograms, rhombus, trapezium, square, rectangle, circle and so on. After designing this, I measured the required lengths of the borderline, noted it in my copy and then I calculated the height, perimeter and area as the requirement. From this effort made by me, I got clear concepts with entertainment regarding the perimeter and area of the different plane figures. I am sure the concepts will be stored in my mind forever*."

From this view, I found that he was so happy while learning mathematics by using a project-based learning approach because he performed his work practically without using rote memorization. Moreover, he learned mathematics indirectly, without any burden.

Likewise, while expressing her views regarding project-based learning in mathematics learning, female participant B said that "*In my experience, the project-based method of learning mathematics incorporates all levels of students. Because of the requirement of active participation in learning, nobody can escape from learning. Everyone should bear equal responsibility in learning on the one hand. On the other hand, we all have to do our duty practically means, which forces us to all indirectly for learning in our own context. Moreover, by designing STEAM projects, we learned many things that were amazing, interesting and effective. I learned the concepts connecting with the different objects available at my home by designing the shapes, drawing, and making on the ground for those to whom it was possible and even by looking at videos and animation of figures with the help of a teacher. The more important thing that I found from this learning is while measuring the boundaries of each type of plane shape, and we used local units (hat, bitta, paila etc.) also for strengthening our concepts. Then after we used standard units for the calculation of required values. The calculation of the values was done from both techniques, one by experiment and the other by formulae and then finally, it was compared for the final conclusion. Besides, by completing each concept, we reflected on it from our side. Such kind of reflections empowered us to strengthen the concept on the one hand. On the other hand, the academic level of all types of students was boosted by this effort as they all engaged in learning equally. In our learning, our subject teacher was a facilitator and scaffolder. As a result, our efforts and activities were guided towards*

content learning not only based on the worked-out examples given in textbooks but also practically connecting with context. However, it takes a long time to complete the lesson; if it has taught all lessons of mathematics by designing projects in the same way, it will certainly be effective, and the deep seated fear about mathematics in the mind of learners will be far. Thus, I was happy and excited to learn with the help of STEAM projects in learning mathematics."

She was also learning mathematics nicely through the project implementation. The more interesting part of this learning technique, according to her version, was that she learned mathematics by connecting with other disciplines, connecting with context and connecting with her interest.

Thus, from all participants' view, the deep seated fear of mathematics in their minds was far with the implementation of PBL, and instead of it, it reproduced fun in their minds. Thus, all participants seem more collaborative, more interactive and more interested in learning.

My Reflections on the Outcomes of Project-Based Learning

I envisaged the vision of project-based learning through the designing and implementation of STEAM projects in teaching mathematics to promote engaged learning in this research. According to the purpose of the study, together with the implementation of the projects, I regularly observed my participants' activities, interactions, responses, submitting an assignment, collaboration in empowering friends and critical reflection in learning mathematics. Moreover, I kept a record of all kinds of activities directly or indirectly. Then after transcribing recordings, coding, categorizing and generating themes, I found that they are positive from different perspectives. Therefore, I have reflected this vision of PBL mathematics in the sense of empowering engaged learning as follows:

Entertainment in Project-Based Learning

I found that learning mathematics using project-based techniques, in particular using STEAM projects, is the best approach to effective and pleasurable mathematics learning. Such a method can greatly help the participants increase their creativity and problem-solving skills. Moreover, they learned mathematics without any burden interestingly. They did their activities practically in collaboration such that it made learning more joyful. They really enjoyed learning mathematics by this method because it made them easier to understand and fun in the learning process.

The use of the STEAM project in mathematics learning empowers and encourages learners. It creates an enjoyable learning environment instead of creating a rote memorization environment in learning mathematics since each individual is made responsible for learning by providing individual duty. Participants enjoyed as they all were engaging in learning mathematics by performing their own duty such as designing, constructing, drawing, measuring, computing and so on. They found the solution for each problem and verified it as well. As a result, they learned mathematics easily and with pleasure.

Excellencies in Project-Based Learning

The PBL supported looking for inexpensive inspiration, creating a bridge between STEAM disciplines and real-world issues and encouraging participants to take and bear risks. It cooperated with the participants to learn practically since the reading book is not enough for the students, and doing practically makes them more creative. Moreover, it helped for a better understanding of subject matters and provided the opportunity for deep learning. Also, it improved teamwork and interpersonal skills as the learning is performed in collaboration and interaction by

the learners themselves. They felt that it is currently essential to build new products and formats in teaching and learning mathematics. By comparing their previous learning approach and this STEAM project-based approach, they found it a new way of creating knowledge. Indeed, in a classroom, there are different categories of students who have different interests and learning abilities: some enjoy learning by the book, whereas some enjoy learning by creativity and their own attempts. This project-based learning is found appropriate and effective for all categories of students. Besides, it promoted learners' creativity, technological advancement and critical thinking as well. It encouraged them practically and creatively, which helped make subject matters easier for understanding. As a result, due to the use of projects, mathematics learning became more interesting and effective for students.

As project-based learning is found more fruitful in developing the concept of engaged learning promoting interdisciplinary and multidisciplinary relationships, this learning approach can be used obviously in the disciplines such as science, social studies, Nepali and so on. Like in mathematics, the learning of other subjects can be made effective and multidisciplinary with the help of project-based learning. Thus, by such designing vision, students can get the opportunity of learning the same discipline from multiple learning approaches, such as the concepts science can be used by relating with social studies, mathematics, arts, technology and so on. For a better understanding of the subject matter of these subjects, it seems effective to use a project-based learning approach. Thus, I agreed with many strong factors of PBL that are found in the implementation of the research.

Project-Based Learning as the Means of Empowerment

The PBL method encouraged the participants to involve themselves in practical work, helped them to a better understanding of the concepts, and made them creative and better in the learning process. The conventional method did not provide them with an in-depth and contextual concept. Using the conventional method, they just used to write and study the content written in the textbook. It never helped me to learn about its importance in real life. It was just like studying the entire course book without any sort of enjoyment in learning. It focused on them just to pass the examination of certain hours by rote memorization technique rather than providing overall concepts for using to solve their real-life problem. As a result, many students felt too difficult in mathematics, and there appeared to be a kind of fear in students towards mathematics. But in project-based learning, they are all commonly engaged to find solutions practically. It created an environment of interaction and collaboration. Therefore, it made the conceptual understanding easy for those participants also who thought mathematics as the subject of difficulty. Nobody felt hesitation or domination in this learning approach.

Also, they got a solution with a deep concept in a new approach to education, and it made learning fun. In addition, the new technique of learning encouraged them to learn the concepts of mathematics from many things available in their daily use. Indeed, they felt it easy to solve the problem since they did practically what they had learnt. Besides, the linkage between different disciplines helps the students for a better understanding of the concepts, making them creative and more collaborative in the learning process. Moreover, as they learned mathematics by linking with other disciplines and with their context, it enhanced their interactive skills, collaborative feelings, practical knowledge, concepts and computation skills as well. Thus, while learning mathematics through project-based

pedagogy, no one thought learning could be done so easily by empowering all students together by means of a project.

It seems that all participants are interested to learn mathematics when they are all involved in the learning. With the application of STEAM projects in teaching mathematics, participants are found to be more interested and excited to learn. They performed their duty with full engagement and entertainment. Moreover, they created the concepts of mathematics strongly with active participation in learning with the guideline of the STEAM projects. Particularly, it is found that they have designed different plane figures, have drawn these figures, they have constructed on the ground as well, have collected daily used objects related to plane shapes, have measured its borders, i.e., boundaries to calculate perimeter and area, they have calculated as the requirement of the problems, and then finally they have verified it with the calculation with corresponding formulae (see chapter VI). All these activities were done by every participant by themselves with interaction, collaboration and active participation under the facilitation of the researcher. From these activities, I concluded that they were empowered and assisted by the PBL approach in mathematics learning.

Project-Based Learning as the Means of Promoting Engaged Learning

As it provided equal responsibilities to all participants in learning mathematics practically, it was compulsory for all participants to perform their duty. They learned mathematical concepts through interactions, collaborations and even by critical reflection. Next, they collected the required ideas themselves, such as they collected the daily used objects related to plane shapes, they designed the different plane shapes, they sketched the related plane shapes, they drew figures of plane shapes, they measured the required boundaries, and then finally, they calculated as the

requirements and verified it (see Annex E). Therefore, all these activities regarding learning mathematics were performed by the participants themselves. For these activities, all participants were equally involved with full excitement and fun. Thus, I ensured that this new vision of learning mathematics promotes engaged learning.

Project-Based Learning as the **Means of Pedagogical Transformation**

On November 1, 2020, at 10 am, I am busy cutting hard paper into different plane shapes such as triangles, rectangles, rhombus, kites, circles and so on. I color it in different colors to make it colorful and attractive. I prepare some videos for demonstrating structural information of some plane shapes relating to others for the purpose of calculating area. Now, I am not only with marker, duster, some slides and whiteboard. I collect many daily used objects representing plane shapes, such as plates, pipes, tea tables, laptop screens, handkerchiefs, artifacts and so on. for the purpose of demonstration that is available at my home. At 11 am, I enter my classroom virtually. Today, I am not teaching them as like previous days. I am just trying to enrich the concepts of plane shapes by different means.

Upon entry to the classroom, I start to ask some unstructured questions (such do you know triangular shapes? Can you find any objects at your home in triangular shapes, rectangular shapes, square shapes, circular shapes, etc.? Did you fly a kite in this year's Dashain and Tihar vacation? Do you know its shape? Did you play cards also at that moment? What about its shape? And so on.) turn by turn to them as my interest in connecting my participants to the topic plane figures. I showed them the pieces of hard paper that I had made before entering the class. I cut again by showing them. With this, I ask them about scissors and paper and tell them to cut with me. My students feel surprised that they do not need to copy any notes in their copy. They are just observing curiously and cutting papers themselves in today's class. I am not

giving specific homework today in my class. I just tell them to bring hard paper and make just five plane shapes by cutting them. With this assignment, I stop today's class. I want to continue this type of classroom still two/three days in my classroom for the purpose of building ideas regarding the topic, and then I want to engage my participants gradually in the lesson by doing themselves.

I presented above my first-day classroom activities in the sense of project implementation in teaching mathematics to Grade IX students. I became a source of inspiration and facilitator in all day's classroom activities. I did not teach them as like before the project implementation. I found all my students (participants) active engagement in learning. They performed their assignments, project works, presentations, etc., in teamwork with interaction, cooperation and collaboration. I just observed and facilitated them according to the nature of the content and demand of the curriculum being with them. Doing so, I found that these activities were directly guided by two major theories: constructivism and transformative learning theory in the sense I engaged my participants to do themselves means they were busy constructing concepts themselves. For this, constructivism fully supported me in this inquiry. Next, rather than teaching students strictly by making them compulsion in memorizing a formula, doing exercises, and submitting homework within mentioned time, I have facilitated, encouraged and boosted them to engage in learning. It means I have changed my pedagogical practices.

In addition, I have chosen this research agenda with a critical reflection on the pedagogical practices of my academic journey (first learning and then teaching). It signified that I was worried about bringing change in my professional practices as well. Therefore, my interest in this inquiry was obviously to transform my educational

pedagogy in my professional life; for this, I found transformative learning theory as the means.

Barriers in Implementing Project-Based Learning

According to my research participants and in my opinion, as well, project-based learning takes a long time to learn mathematics since it promotes a deep learning environment. As the existing course of mathematics is decontextualized and the same all over the country, it will be difficult to complete the course and follow the structured academic calendar. Next, I felt it is a bit expensive procedure from the perspective of managers, such as managing different instruments, devices, materials and so on.

Since the education system of each school is running according to the national education planning and national curriculum framework, I felt a bit technical to implement project-based educational pedagogy in the sense that by designing STEAM projects, engaging students in the designing process and making a deep understanding of the mathematical concepts the running education system cannot support. At first, my students, their parents, the school administration, other teachers and members of the school management committee all were unknown of this practice. Due to that, it took a bit of time to convince them. Yet, they used to say that due to the COVID pandemic, the failure rate in mathematics in most of schools is a bit more on the one hand. On the other hand, if the course will not be completed on time, in their view, the situation becomes dangerous in the field of mathematics. Therefore, to aware them regarding this new concept of learning mathematics, it took time for me. Thus, the deep-seated beliefs and existing pedagogical practices guided by our national education system stood in beyond STEAM pedagogy.

In new practices, it is obvious that the supports and guidance in his/her local context are essential to anyone initiator. But it was a lack in the area of my professional practices. However, I was fully supported by the ideas that I created from my MPhil learning journey. Besides, designing the appropriate STEAM projects for each concept of mathematics and implementing it in professional life by following the national curriculum framework, I found impossible in my local context due to the lack of sufficient time, sufficient ideas regarding the connection between STEAM disciplines, available sources in school and so on. Therefore, the incomplete and insufficient knowledge of designing a project and its implementation is another obstacle in developing the ideas of PBL (see chapter VI).

Wrapping up of the Ideas

My research participants seem to be excited and hopeful about the application of PBL. They argued that PBL is very effective as it helps to gain practical concepts and makes them clear the concept which they felt harder before in the conventional teaching approach. According to them, it helped them to enhance their creativity, strengthened conceptual organization, and empowered their skills in solving real-life problems. It not only helped in learning mathematics by establishing the relationship between multi disciplines but also encouraged them to learn in their own context through interaction and collaboration. It can be clearly seen from their project work (see annex E) their activeness during the research process, their submission of assignments, their presentation in the classroom and so on.

In addition, it boosted the learning in the sociocultural environment as the wish of participants, i.e., it empowered the learning to make contextual. As a result, all participants felt the learning according to their interests, and nobody escaped

from the learning. Instead of feeling fear of learning mathematics, they argued that they learnt mathematics with full enjoyment by doing practically.

Moreover, they felt fun learning mathematics by connecting the concepts with STEAM disciplines as well as to their daily life. Next, they were fully engaged in learning through different practical works due that they felt were easy to learn. Another more important attempt in the learning was participants were encouraged by the help of the researcher as the facilitator rather than the rude content teacher of mathematics. By learning the same content from different perspectives, such as using the concept of integrated STEAM pedagogy also, the learning became more remarkable to them. Besides, it was beyond their habitual learning pedagogy, where they learned mathematics in the pin-drop silence environment as passive listeners. Comparatively, the new technique of learning provided the participants with more freedom to be empowered in learning. Therefore, they all agreed that PBL was the best technique for learning mathematics. However, they got some oddness and difficulties at the time of designing and implementing the projects.

Bridging to the Next Topic

With the implementation of the STEAM projects in learning mathematics according to the requirement of my research purpose and research questions, I explored some remarkable reflections from the angle of my research participants about what they felt while learning mathematics from a project-based approach and even from my own side by observing their activities, their assignments, their efforts in learning mathematics, their ideas that they shared in a group, their submitted project work (see Annex E) as well as by experiencing their activeness conceptual understanding of mathematics. Besides, I have critically reflected on my previous

conventional educational pedagogy and this new practice while teaching and learning mathematics. Next, I have viewed my opinion and shared my experiences based on the performing academic activities of the research participants under the criterion included in the evaluation sheet (see Annex F). In the next chapter, I have envisaged overall reflections and conclusions based on the reflections made in this chapter.

Chapter Summary

In this chapter, I shared the ideas guided by the reflections of my research participants based on their views on PBL in mathematics. For this, I used the conversations of four representative participants taking their pseudo name and also through the views of two participants: one male and the other female. Moreover, I articulated my reflections on the outcomes of applying PBL as the demand of my inquiry by means of transcribing, coding, categorizing and generating the theme of the information gained from various sources. I included different aspects of PBL while reflecting from my side. Besides, I did not explore only the excellencies of the PBL, and I have demonstrated the barriers as well that I faced while using STEAM projects as the educational pedagogy in the mathematics classroom. Moreover, I included how project-based learning in mathematics promotes engaged learning in this chapter.

CHAPTER VIII

CONCLUDING MY JOURNEY

Chapter Overview

I have presented my participants' reflections guided by their experiences towards the new practices of mathematics learning by using the STEAM project according to my research issue in the previous chapter. Likewise, I have demonstrated my reflections regarding project-based learning in mathematics classrooms by designing and applying STEAM projects with my participants.

This chapter is developed for the overall reflections of my inquiry process from the research agenda to the end of the research. Here, I have explored the overall efforts made in my research from the beginning to its end.

Next, this chapter has included envisioning project-based learning in my inquiry, reflecting on theoretical referents, reflections on the methodological map, responding to my research questions, key learning generated from research, conclusions, implications and futures directions of the research i. e. overall reflections gained from research.

Envisioning of Project-Based Learning in My Inquiry

The issue of my inquiry was born due to the decontextualized and disengaged learning world that I explored in previous (see chapters, I & IV). I experienced a similar type of learning culture from the beginning of formal education to even a master's degree, where my teachers used to force and guide students to pass the examinations and honor the degrees of different levels rather than making meaningful and contextual learning.

Moreover, our teachers were guided by the structured curriculum, fixed academic calendar and pre-determined written examination of certain hours. I experienced from my learning journey that the environment of students' active engagement, interaction, collaboration, application of design thinking in mathematics learning and active enrolment of the students in knowledge construction procedure was beyond imagination due to many obstacles. However, I completed all my levels up to my master's degree with a so-called excellent score in mathematics in the view of dedicators.

With the dissatisfaction of the learning world and many unanswered questions, such as Is there any easy technique for learning mathematics? Why can students not be enrolled in learning mathematics? Can we connect it with our practical life? and so on.; I joined my professional life by teaching school-level mathematics from the beginning of the bachelor's level. I tried to make active enrollment of students in learning mathematics even by using relevant teaching materials in classroom teaching. But project design and its uses in teaching mathematics were beyond my professional practice due to the lack of ideas regarding it. Moreover, I did not get any supporting environment for learning such ideas of managing classroom activities up to my master's degree; however, I was excited to engage my students in my classroom to make effective learning. Thus, it was an initial step indirectly for the inspiration of my research empowering engaged learning.

With the hope and excitement of changing my pedagogical practices after the enrollment of more than fourteen years of professional life, I felt the need for higher-level education, and I got admission to MPhil level under STEAM Education at Kathmandu University, School of Education. It was an integrated multidisciplinary and interdisciplinary course in which, while learning the disciplinary contents, the

linkage with other disciplines was established. It was a new practice in our context. With the initiation of my MPhil learning journey in this genre, I was encouraged and motivated mainly by two factors: first, the role of professors as the facilitators and second, the nature of the course. I got the opportunity of learning the ideas of many authors as well as my vision regarding the active participation of students in learning mathematics was cultivated by the different visions and ideas shared by professors in the learning process day by. As a result, I concluded to choose PBL as the research agenda to promote the engagement of the students.

In this sense of completing my inquiry, I envisaged the vision of PBL in the mathematics classroom by developing STEAM projects. I attempted to design STEAM projects by connecting the concepts of STEAM disciplines at first, and then I implemented it in the classroom practices promoting engaged learning of the participants. From this effort, I experienced that it was a great opportunity for me to change my professional practices through the themes generated from my research.

Reflecting on Theoretical Referents

My research was guided by two major theories: constructivism and transformative learning theory. In my research, participants have engaged in knowledge construction themselves. Therefore, constructivism was used as one of the guiding theories. Likewise, my research participants constructed the knowledge through interaction, collaboration, and critical reflection. I was a facilitator rather than a mathematics teacher. Besides, with the objective of the study, my interest was to transform my professional practices as well. Therefore, it was guided by transformative theory also.

I was in the role of the scaffolder in my research. Indeed, it was verified from the research that knowledge is in the process of construction but not possible to give

by anyone, which is the main theme of constructivism. Also, my research participants and I altogether treated learning as an active process in the context of individual gain through group efforts. However, knowledge becomes personal (Kurt, 2021). Thus, as my agenda of study required the active involvement of students to construct knowledge through engaged learning, constructivism learning theory helped as a guiding theory to complete my research.

Next, the agenda of the research was to empower engaged learning through the dialogic process rather than the banking approach. For this, I was inspired by Mezirow's transformative pedagogy because my objective was to shift my own and my participants' beliefs, practices and assumptions. It seems that the education of this 21st-century is not limited to a classroom only but seeks to contextualize with the surroundings and people involved in the learning. This kind of message was unpacked in my study. Therefore, for this, I was encouraged by transformative learning theory due to the efforts of Mezirow and Marsick in 1978 as a particular type of adult learning theory. Besides, the transformative learning theory articulated by Mezirow relies on the theory guided by the emancipatory interest of Habermas (1968), including particular types of conversations (discourses) which are free, open and active participatory. Therefore, in the sense of learning the concept of mathematics, different discourses and participants' free conversations were included in my research.

As the requirement of my study was an active and engaged learning environment with critical discussion and searching for additional information from other sources as well as those given in a curriculum for a better understanding of the concepts, for this, I was fully supported by this learning theory. Besides, it enabled my participants to know about themselves by relating with others and the natural

world for the aim of shifting paradigms (Bourn & Soysal, 2021) as well. As a result, they fully engaged in learning with interaction, collaboration and in inquiry-based learning. Moreover, it empowered them to critically reflect on their deeply seated values and beliefs regarding pedagogical concepts (Taylor & Taylor, 2019) and shift to project-based learning.

Furthermore, it created a guideline for the completion of the research in three major criteria: at first, the learning should address the interest of learners empowering activeness, interaction and collaboration such that concepts are constructed (Christie et al., 2015). Second, open and voluntary discourse is most in transformative learning for the purpose of examining and updating existing assumptions, values, beliefs, ideas and feelings (Schnepfleitner & Ferreira, 2021). Finally, it is necessary to create an opportunity for the learners to reflect critically individually or in a team. Thus, under these criteria, my research participants became conscious of their personal knowledge and changing views, and they experienced transformation (Rajbanshi & Luitel, 2020) in the learning process.

Reflecting on My Methodological Map

My research methodology is guided by autoethnographic action inquiry. Autoethnography is used as the research methodology, and inside it, since I wanted to revise my professional journey, so, action inquiry is linked with it. For the purpose of addressing autoethnography, I have unpacked my experiences of the academic world with the help of stories, poems, figures, dialogue, monologue and so on. For the autoethnographic part, i.e., for employing the artistic process of investigation (Barone & Eisner, 2006) in my inquiry, I was attracted to autoethnography.

My starting journey of professional life, my interest and initial journey regarding the MPhil level at Kathmandu University, how I was inspired and

encouraged by the education provided by the University, along with my decision of choosing research agendas, my attempts in completing research according to my purpose, the decision of transforming pedagogy in daily practices, etc. are explored under my narratives in the process of addressing research questions. Moreover, I was inspired in my research methodology by the idea of Luitel (2009) because autoethnography promoted me in transgressive ways of knowing, including interpretation, self-reflection, deconstruction and motivated storing arising mainly from interpretivism, criticalism and postmodernism.

According to my research purpose, to empower project-based learning in mathematics classrooms, I designed STEAM projects in teaching mathematics, and I implemented them in my 30 days of classroom practices. Doing so, I was devoted to fulfilling the action inquiry part of my inquiry.

Responding to My Research Questions

This section summarizes how I responded to the research questions of my research in order to complete it based on the development of research questions, selection of guiding theories, and selection of methodological directories.

For the purpose of addressing the first research question, I explored my lived experiences being a student of different levels, from primary education to MPhil. I explored the culture of providing education to the students that I experienced from different levels of education. In order to express my lived experience as the indirect answer to the first research question, I chose narratives, poems, dialogue, figures, metaphors and monologues as well. Furthermore, I explained my journey of empowerment regarding engaged learning through Kathmandu University as a learner of M.Phil. level. Also, I included my experience of teaching students as a

conventional practitioner before engaging in M.Phil. level to demonstrate my connection to disengaged learning.

Likewise, for addressing the second question of my inquiry, I expressed my attempt to shift my pedagogical practice to empowering engaged learning by means of a project-based approach. In addition, I included my plan with my STEAM projects of teaching mathematics regarding the ideas of promoting mathematics learning through the concepts of project-based learning, concepts of connecting different disciplines in learning mathematics, ways to promote the students' engagement in learning and performing the activities to achieve the common goal of learning and so on. Moreover, this section explored the procedure of developing the notion of PBL in my efforts according to the agenda of my inquiry.

I addressed the third research question by mentioning the implementation process of my project in the mathematics classroom. For this, I explored my attempts at contextualizing mathematics through STEAM projects as well as my attempts to encourage the engagement of the participants in learning mathematics by categorizing it into four phases. According to these divisions of different phases, nobody could escape learning. In addition, I included the activities of participants at the time of learning mathematics using projects through their dialogue and even poetic representation.

Finally, I have mentioned my participants' reflections by means of their dialogue, individual opinions, activities during learning, their responses in my regular unstructured interviews, their learning excitement in learning, their submitted assignments based on learning, their performance in my regular evaluation and their responses in the open questions in the google form in the previous chapter. Also, I have explored my own reflection about project-based learning based on my

involvement with the participants in the sense of designing and implementing STEAM projects while teaching mathematics in the chapter. With the inclusion of responses to all research questions, I have reached the conclusion of this scholarly work.

Key Learning

This study has created a platform for knowledge enhancement as it carries the concept of project-based pedagogy in a mathematics classroom in our context. It empowers the concept of STEAM projects as I have designed STEAM projects to use mathematics classrooms to enhance engaged learning. I got the opportunity of looking back on my life and learn the ideas of transforming into a new genre from my lived experience of learning about my past. I realized that the procedure these days was a disengaged and passive way of transmitting knowledge from teachers to students. However, the culture, context and curriculum of our daily use seem responsible for this kind of learning approach; it has become essential to make each individual able to solve their real-life problem through the means of learning. For this, the conventional approach to learning seems unpractical and unusual to them. Thus, through the means of this research, I demonstrated the ways of using project-based learning in empowering students' interaction, collaboration and critical reflection. From this, I learned different ideas shared by others as well in project-based learning.

Furthermore, by means of this study, I initiated the design of STEAM projects by establishing the relationship between mathematics and other disciplines such as science (for measurement systems), technology (for presenting power point, videos, figure animation, etc.), engineering (for designing different plane shapes), and arts (for drawing and sketching different plane shapes). From this attempt, I learned and generated a new idea of connecting one discipline to others. Also, I used the designed

projects in classroom teaching, and I got the chance to observe participants' reactions, excitement, teamwork, collaborations and engagement in mathematics learning. I directly experienced the effectiveness of using PBL in classroom teaching.

By involving in the projects with the participants, I observed their activeness in learning, their conversation regarding learning, their submitting assignment and even their classroom performance. I found it in the empowerment of their learning from active engagement. I learned from it that a pedagogical shift is required for effective learning. Besides, I was inspired to organize engaged learning instead of treating students as passive listers. Likewise, I figured out that every learner has the potential to do best in the learning disciplines. However, they require an appropriate learning environment to boost up. The change that occurred in the learning interest of the participants by means of the projects allowed me to see that project-based learning can be the best alternative for empowering engaged mathematics learning.

CHAPTER IX

CONCLUSIONS

My learning journey of mathematics from school to even to master level was boosted by piping learning (Luitel, 2009) approach; I did not get two ways interaction, collaboration and a critically reflected learning environment. I felt several failures in mathematics in each class in one hand. On the other hand, teachers used to deliver content to complete courses ignoring the needs and interests of the students.

My professional journey started with the learning of university-level education. I tried to understand my students, and I succeeded in passing the students with so-called outstanding scores. I felt it was too difficult to make able to pass some students who were not performing their work regularly. At the same time, I used to raise different questions within myself about making interested to all students towards learning. Along with this type of thought within myself, I completed my master's degree, and I started my professional journey at a higher level as well. But, yet, I was not satisfied with the technique of classroom teaching.

With many bundles of dissatisfaction within my mind, I entered Kathmandu University School of Education; for the purpose of MPhil learning, where I enjoyed learning with full interaction, collaboration and critical reflection. I am highly inspired by this environment. As a reflection of it, I chose the related research topic to empower engaged learning from a project-based approach. I generated the problem of research mainly from three perspectives: conceptually, contextually and empirically. I constructed the research purpose based on my research agendas and created research questions to fulfill the purpose of the research.

With the construction of research questions, I chose constructivist and transformative learning theories to guide my research. Also, I took interpretivism, criticalism and post-modernism as the research paradigm. Because of my interest in bringing change to my professional life, I chose autoethnographic action research as the research design. This methodology empowered me to conduct research from my own lived experience of the culture of learning mathematics on the one hand. On the other hand, to make the change in my professional practice, I was assisted by it.

At the beginning of addressing the research agenda, I explored how I connected with disengaged mathematics learning from my own experience of different levels of formal education. I used story, dialogue, poem, monologue, etc., for expressing it. Also, I explained the learning culture that I got during my learning journey in-depth. Besides, I mentioned my learning journey at the MPhil. level and its contribution in encouraging me for developing the vision of engaged learning through projects, planning of developing projects and its implementation in classroom practice.

I planned to introduce project-based learning in mathematics classrooms by means of STEAM projects, where the STEAM projects were designed by connecting the concepts of mathematics with science, technology, engineering and arts. Then, used it in 30 days of classes for learning mathematics. In each day's class, I just explained the requirements of the participants and what they have to do in learning. I was just a facilitator of each day's learning. Moreover, I briefly explained the multidisciplinary relationship such as by designing approach, drawing, figure animation, videos and so on. I made responsible to each individual perform their duty. I provided assignments to do practically at the end of each concept.

During the learning time, I continuously observed their activities, their excitement in learning, their creativities, interactions and collaboration in learning virtually. I took an interview regarding this approach to learning. I made it compulsory for them to fill up their experiences in the google form by means of some open questions at the end of each concept. I asked them cross-questions in between the learning frequently.

I found that all participants were engaged in learning with full excitement and entertainment. They felt fun in designing, drawing, sketching, measuring into different units, noting in the diary and then calculating as required. Also, they checked their calculations by using related formulae to determine the correctness. Moreover, they were discussing by conducting virtual meetings in between their groups about learning agendas. In addition, I ensured that they were engaging in learning with full effort as I found positive responses to my questions from all participants. I found not only their admirable participation in learning but also, I got their creative performance in the assignment.

Their collection of daily used objects, their measurements, calculations, verifications and concepts formation was too interesting. The participants, who used to escape from learning and submitting assignments in the conventional learning approach, were performing their tasks. At first, it was a remarkable point of project-based learning. Likewise, they felt full enjoyment due to the connection of mathematics with other disciplines as well because they never did it in the conventional method of learning. It is another strong point for supporting why to use of STEAM projects in learning mathematics. Yet, the mind-blowing performance of the participants' which I experienced from project-based learning, is that the

participants who used to be afraid of mathematics before were also performing their duty with excitement in the project.

Moreover, it is found that the use of STEAM projects in mathematics classrooms empowered participants in the process of generating knowledge. In the conventional approach, learners were treated as passive receivers, but in this project-based technique, they are treated as active knowledge creators. As a result, I found that each individual contributed equally in the sense of problem-solving and learning as well. Therefore, I concluded that the application of projects in mathematics teaching as well as learning is fruitful to make learning more engaging, to learn in-depth concepts of mathematics and to make able to our students for solving real-life problems; however, it requires more time, more efforts, more exercises and well-trained teachers in its application. Besides, to uplift the achievement of students in mathematics, the implementation of the projects seems one of the best solutions for engaging students.

Implications

I have made an effort regarding the possibilities of applications of my research conclusion in this section. I envisaged that my tiny efforts made through this study could become a guideline for addressing the problem of disengaged and decontextualized mathematics practice in our context. I came up in this section with some visions for developing an engaged mathematics learning environment. Primarily, I have identified that the application of STEAM projects in teaching mathematics is appropriate for the empowerment of engaged mathematics learning. Therefore, as I am working as a teacher and teacher educator, it can be implemented in my own future professional life as well. Also, as I used stories, poems, dialogues and monologues as the means of sharing my experiences and my participants'

experiences, I hope that strengthening the logic empowers me in my present and future professional life to be more transformative. Likewise, I used STEAM projects as means for envisioning an engaged PBL. These concepts can be improvised in the future for personal and professional outgrowth.

Furthermore, I ensured that my research texts could be used as a referent for transforming the professional practices of mathematics educators of similar professional contexts. For instance, my idea of designing STEAM projects and their implementation can be used to shift the educational pedagogy of mathematics teachers and teacher educators in their teaching to promote students' interactions, collaboration and critical reflections. Next, the texts of my inquiry (e.g., stories, poems, dialogues, monologue, reflective genres) unpacked in the different sections of this dissertation become a guideline for teacher educators in creating teaching mathematics contextually and conceptually to all levels of students from the perspective of holistic development.

Next, my discussion and articulation of shifting pedagogical vision, i.e., the transformative pedagogical vision of teaching mathematics, empowered me to develop such a curricular framework to encourage engaged learning at the time of designing the curriculum. Moreover, I argued that such visions further help planar and policy maker because such a vision of education becomes a basis for interconnecting different disciplines with a single subject to strengthen it. I envisaged a set of logic, such as poetic, dialectical, narrative, etc., in the study, which offers to develop contextualized and engaged plan, policy and even a curriculum of mathematics.

In the context of developing the concept of mathematics-engaged learning locally and globally, my articulation of designing the project and its implementation became a pathfinder. In addition, the idea of transformation from a conventional one-

way traffic system to engaged project-based learning in mathematics entails structural shifts in thinking and actions of educators, planners, policymakers, teachers, teacher educators and students as well by promoting their critical, creative and holistic approach of empowering achievement in mathematics education.

Also, I envisaged that the progressive researchers who want to generate data from my professional experiences could use my research process and product in a similar context. I do not mean that the method of my inquiry to be copied by the other researcher. Nevertheless, it is possible in a similar context to encourage the researchers for shifting their professional practices following a similar methodology.

Future Directions of My Inquiry

I have envisaged and initiated the vision of project-based learning promoting STEAM pedagogy in the mathematics classroom by means of this inquiry. Indeed, engagement and collaboration among the students seem crucial to enabling them for solving their real-world problems by means of their learning. Guiding with this idea, I have conducted this inquiry with the aim of promoting the active engagement of the students. Besides, I have initiated the designing thinking in the mathematics classroom by means of STEAM projects in this inquiry. However, I felt some issues that remain to address by the inquiry due to various known and unknown factors.

I have designed the STEAM project of my inquiry in the limited ideas and limited content area, including the concept of perimeter and area of plane surfaces. I have used virtual means to enhance the knowledge about plane shapes, engage students in the project, observe their overall activities, and even collect information due to the COVID-19 pandemic. Moreover, I have used the single cycle of action inquiry to complete the requirement of action research and to shift contemporary and

disempowering pedagogical practices. In this regard, this inquiry is my first attempt to bring change in my personal and professional contexts.

In my case, however, I have started such a significant step to shift my professional practices. I commit within myself to continue this transformative movement of educational pedagogy by means of STEAM projects, performing my numerous responsibilities. Thus, by supporting these attempts to complete my dreams of transformation, if I get an opportunity to enrich my idea by means of PhD, I would like to address the limitations of my journey that I mentioned in this text on the one hand. On the other hand, I would like to make a further effort in the transformative movement of pedagogical practices.

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ANNEX - A

INTERVIEW GUIDELINE

1. Did you feel entertainment in learning mathematics using STEAM project? Give your view.
2. What pros and cons of offering project-based learning did you see?
3. Which method first one (conventional) or second one (project-based), you felt more effective in your mathematics learning? Why?
4. Can we use this method in the learning of other subjects (such as Science, Social Studies, Nepali, English and so on.) also? Give your view.
5. What can be improved to make more effective project-based learning in your view?
6. Does the STEAM project assist you in easy learning of mathematics? How can you claim it?
7. Reflect your view on the effectiveness of this kind of multidisciplinary and integrated practice in learning mathematics.

ANNEX - B

FOCUS GROUP DISCUSSION GUIDELINE

1. How is your feeling towards project-based learning?
2. Are you enjoying in learning mathematics? If yes or no why?
3. How did you develop the concepts of designing plane figures in your learning? Explain it.
4. What pros and cons of offering project-based learning did you see?
5. Which method first one (conventional) or second one (project-based), you felt more effective in your mathematics learning? Why?
6. Can we use this method in the learning of other subjects (such as Science, Social Studies, Nepali, English and so on.) also? Give your view.
7. Do you have any suggestion regarding this method of learning? Mention it.
8. How does this type of learning mathematics enable all types of learners in the classroom in your view?
9. Did you feel yourself, a more collaborative and interactive in this method? Why?
10. What are the differences you felt in performing assignments in this method?
11. Did you enjoy while sharing your ideas to the other friends? Why?
12. Reflect your view on the effectiveness of this kind of multidisciplinary and integrated practice in learning mathematics.

ANNEX - C

GOOGLE FORM

Dear students, this form is developed just for the purpose of measuring the effectiveness of this new approach of STEAM based learning based on our activities. Therefore, you all are suggested to fill this form including your real feelings and experience towards this learning approach. All information will be secret.

Name: …… Class: ……..... Gender: ……

1. Are you enjoying in learning mathematics by this method? If yes or no why?

……

2. What are the major ideas regarding this new approach of learning? Can we learn other subjects such as science, social studies, nepali etc. by this approach? Give your view.

……

3. What are the strong and weak aspects of this approach of learning?

……

4. Which method (conventional or new) of learning did you find more fruitful and why?

……

……

5. Reflect your view on the effectiveness of this kind of multidisciplinary and integrated practice in learning mathematics.

……

……

ANNEX - D

STEAM PROJECT

Subject: Compulsory Mathematics Grade: IX

Topic: Mensuration (Perimeter and area of plane figures)

Instructional Time: 30 Periods

Intended Learning Outcomes: With the engagement in the learning mathematics by project-based learning using STEAM project my research participants will be able to:

- ❖ Identify the daily used objects representing different plane shapes.
- ❖ design various plane figures (triangle, rectangle, square, parallelogram, rhombus, quadrilateral, trapezium and circle) by cutting hard paper, drawing in paper as well as using matchstick/toothpicks.
- ❖ measure the boundaries (edges) of such plane figures using local units (such as hat, bitta, paila) as well as standard units (such as meters, centimetres etc.).
- ❖ calculate the perimeter and area of plane surfaces (triangle, rectangle, square, parallelogram, rhombus, quadrilateral, trapezium and circle) from experimentally as well as conventionally.
- ❖ establish the relationship between the areas of two plane figures (such as area of triangle and parallelogram; area of rectangle and circle).

- ❖ design the concept of three types of pathways (outer path, inner path and cross path) by the help of hard papers, handkerchief, ground nearby house and computer as well.
- ❖ calculate the area of pathways (outer path, inner path and cross path) from experimentally (measuring) as well as conventionally (by formula).
- ❖ solve the real-life problems as well as the problems given in textbook related to area, cost and quantities.
- ❖ solve the problem in integrative way and introduce sociocultural integration of mathematics (such as connecting with the shape of tapari, bota, nanglo, pujako thali etc.).

Pre-Knowledge: Students are expected to be familiar with the concepts of plane figures, some solids having plane figures as the faces and their dimensions and measurements as well as related formulae.

STEAM Areas:

Science: The concepts of measurement and its units (such as fundamental and derived unit, their conversions), scaling in local unit (such as hath, bitta, paila) in standard units such as MKS or metric system, FPS system, & CGS system.

Technology: Use of power point, animations, videos etc.

Engineering: Designing plane surfaces, pathways and sketches from hard paper sheets, using matchstick/toothpicks as well as on the ground nearby house.

Arts: Drawings and colouring of various plane figures, paths etc.

Mathematics: Dimensions will be measured and calculated as per the requirements. Also, related formulae will be verified.

Guiding Questions:

- What are the plane figures as mentioned (in syllabus)?
- How to measure its boundaries and convert its units into different units (such as fundamental and derived units, their conversions)?
- How to calculate the perimeter and area of the different plane figures?
- How to calculate the perimeter and area of the different plane shapes available in our daily life?
- How to design the different plane figures?
- How to calculate area of plane figures?

Materials Needed:

- Laptop, Basic Calculators, measuring tape, scissors, hoe etc.
- Models of daily life used materials representing different plane figures.
- Hard paper sheets, pieces of carpet, rugs etc.
- Pencil, scale, thread, markers, glue, pin, erasers, matchsticks/toothpicks etc.

Teaching and Learning Activities:

- Teacher will examine the concepts of different plane figures in students through interaction, discussion, collaboration, displaying plane shapes by cutting hard paper and so on.
- Teacher will guide to draw different types of plane figures in paper sheet as well as in computer.

- ❖ Teacher will guide to design the different types of shapes using hard paper sheet.
- ❖ Teachers will encourage to design it through ppt with drawing, animation, and videos using GeoGebra.
- ❖ Teachers will guide to measure the boundary edges by scale in case of pictures and by measurement tape in case of models of such plane figures.
- ❖ The concepts of measurement and its units in local units (hat, bitta, paila), in fundamental and derived unit with its conversion.
- ❖ Teachers will encourage to calculate the perimeter of such different plane figures and to derive the different formulae for different types of plane figures.
- ❖ Teachers will guide to calculate area of different plane figures.
- ❖ Teachers will encourage to develop the model of outer path, inner path and cross path of uniform width taking certain place as the ground of rectangular shape inside the compound of their house.
- ❖ Students will be actively involved to measure the lengths and breadths of such designed ground including path and excluding path using measurement tape.
- ❖ Students will be actively involved to measure the lengths and breadths of such designed ground including paths and excluding paths using scale.
- ❖ Students will be encouraged to calculate the area of inner path, outer path and cross path from their own calculations and then to verify it using related formulae as well.

Assessment:

- ❖ Identify and prepare the list of different daily uses goods representing plane figures (such as triangle, quadrilateral, rectangle, circle etc.).
- ❖ Design different plane figures using local materials such as matchsticks/toothpicks, hard paper sheet etc.
- ❖ Measure the edges of such designed plane figures in local units (such as hat, bitta, paila) as well as in standard units/derived unit.
- ❖ Calculate perimeter and area based on the measures obtained.
- ❖ Design rectangular and circular sketch inside the compound of their house using white dust or flour or rope and then inner path, outer path and cross paths of uniform width.
- ❖ Measure the boundaries of such sketch using measurement tape including paths as well as excluding paths to calculate the area.
- ❖ Use handkerchief to broaden the concepts of different paths and its area.
- ❖ Solve the problems given in your textbook.
- ❖ Students will be required to perform some assignments based on the following project work:

Project Work

1. **Design and Creation:**

……

……

2. **Art Integration**

……..

……..

3. **Activities**

……

……

4. **Reflection**

……

……

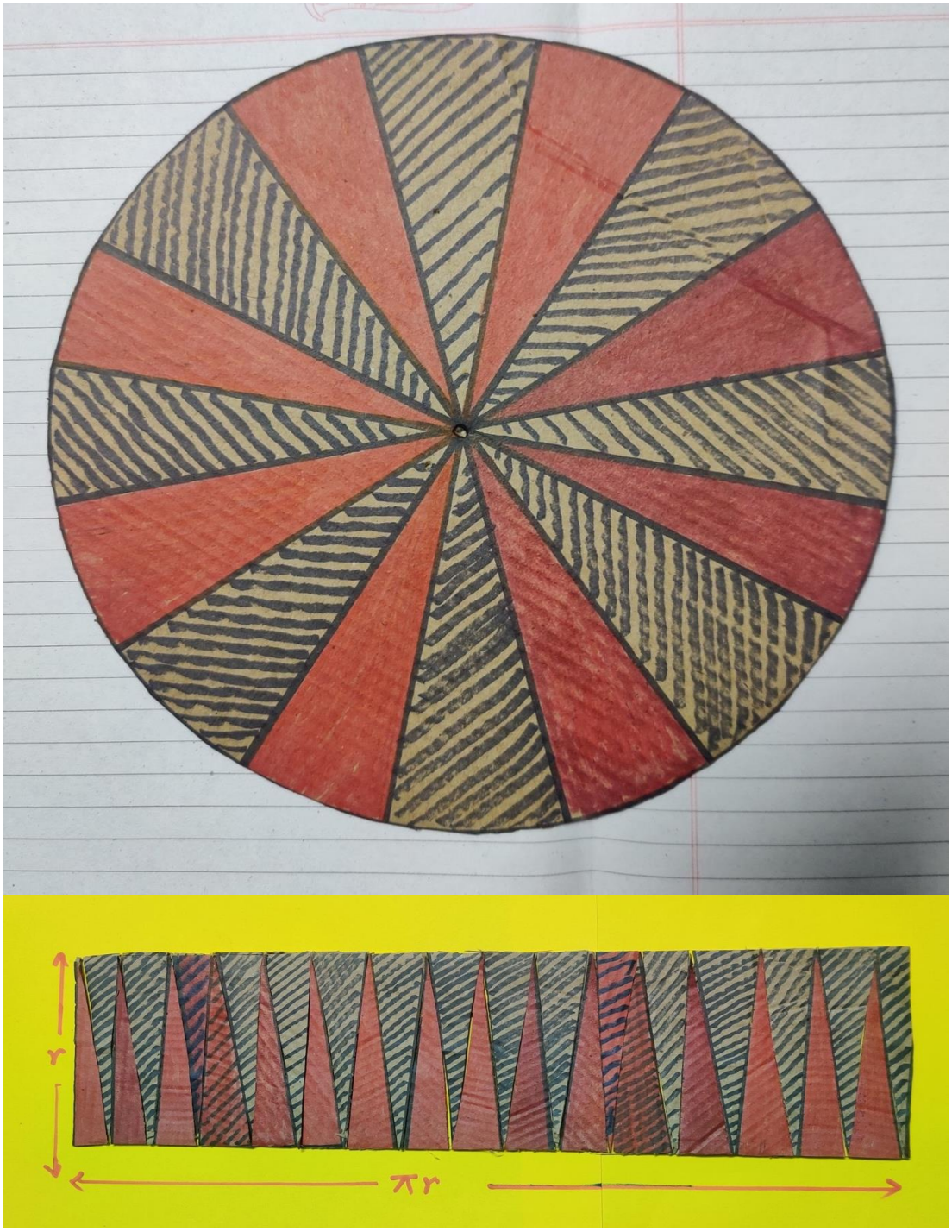
5. **View towards Project Work**

……

……

ANNEX - E

SAMPLE PROJECT WORK - 1



Project Work

1. **Design and Creation :**
I have designed a circle with radius 14cm by a hard paper sheet for the purpose of finding area reducing into rectangle as shown in above figure / photograph.

2. **Art-integration :**
I made 32 isosceles triangles taking centre of the circle as the vertex and coloured them alternately by two colours to make two distinct sets triangles.

3. **Activities :**
- I cut it and divided into small triangles taking centre of the circle A as the vertex.
- I arranged such pieces into rectangular shape such that both sides contain same number of distinct coloured triangles.
- I measured the length and breadth of the rectangle and plotted as shown below table :

Table of Verification

Name of Plane Shapes	Dimensions	Area
Rectangle	$l = 44\,cm$ $b = 14\,cm$	$A = 44cm \times 14cm$ $= 616cm^2$
Circle	$r = 14cm$	$A = \pi r^2$ $= \frac{22}{7} \times (14cm)^2$ $= 616\,cm^2$

4. Reflection:
I found that area of circle is easy to calculate by reducing it into rectangle such that length of the circle becomes half of the circumference of the circle and breadth of the rectangle becomes radius of the circle.

5. View towards Project work:
It is helpful to strength the concept from practical perspective.

SAMPLE PROJECT WORK - II

Project Work

Date
Page

1. Design and Creation

I sketched a rectangular shape on the ground inside the compound of my house. Next, I designed a path surrounding it inside the rectangle.

2. Activities

- I measured the length and breadth of the ground including path and excluding path in local units (hat, bitta and paila)
- I measured the width of the path in local units (hat, bitta and paila).
- I measured the length and breadth of the ground including path and excluding path in centimeter. Also, I measured the width of the path in centimeter.
- I calculated the area of the ground including path and excluding path by using local units as well as centimeter.
- I also calculated the difference between the areas, including path and excluding path.

I have presented the both types of calculation as below:

For local units

length of ground with path (l_1) = 10 bitta
Breadth of ground with path (b_1) = 7 bitta
Area of ground with path (A_1) = $l_1 \times b_1$
= 10×7 (bitta)^2
= 70 (bitta)^2

Date
Page

length of ground without path (l_2) = 8 bitta
Breadth of ground without path (b_2) = 5 bitta
Area of ground without path (A_2) = $l_2 \times b_2$
$= 8 \times 5 \text{ (bitta)}^2$
$= 40 \text{ (bitta)}^2$

∴ Area of inner path (A) = $A_1 - A_2$
$= (70 - 40) \text{ (bitta)}^2$
$= 30 \text{ (bitta)}^2$

Similarly,
length of ground with path (l_1) = 7.5 paila
Breadth of ground with path (b_2) = 5.25 paila.
Area of ground with path (A_1) = $l_1 \times b_1$
$= (7.5 \times 5.25) \text{ (paila)}^2$
$= 39.375 \text{ (paila)}^2$

length of ground without path (l_2) = 6 paila
Breadth of ground without path (b_2) = 3.75 paila
Area of ground without path (A_2) = $l_2 \times b_2$
$= 6 \times 3.75 \text{ (paila)}^2$
$= 22.50 \text{ (paila)}^2$

∴ Area of inner path (A) = $A_1 - A_2$
$= (39.375 - 22.50) \text{ (paila)}^2$
$= 16.875 \text{ (paila)}^2$

Again, length of ground with path (l_1) = 4.286 hat
Breadth of ground with path (b_1) = 3 hat
Area of ground with path (A_1) = $l_1 \times b_1$
= 4.286 × 3 $(hat)^2$
= 18.37 $(hat)^2$

length of ground without path (l_2) = 3.43 hat
Breadth of ground without path (b_2) = 2.14 hat
Area of ground without path (A_2) = $l_2 \times b_2$
= 3.43 × 2.14 $(hat)^2$
= 7.34 $(hat)^2$

∴ Area of inner path (A) = $A_1 - A_2$
= (18.37 − 7.34) $(hat)^2$
= 11.03 $(hat)^2$

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For derived unit i.e. centimeter

length of ground with path (l_1) = 150 cm
Breadth of ground with path (b_1) = 105 cm
Area of ground with path (A_1) = $l_1 \times b_1$
= 150 cm x 105 cm
= 15750 cm^2

length of ground without path (l_2) = 120 cm
Breadth of ground without path (b_2) = 75 cm
Area of ground without path (A_2) = 120 cm x 75 cm
= 9000 cm^2

∴ Area of inner path (A) = $A_1 - A_2$
= 15750 cm^2 - 9000 cm^2
= 6750 cm^2

Using Direct Formula :

length of ground with path (l) = 150 cm
Breadth of ground with path (b) = 105 cm
Width of path (d) = 15 cm
By formula,
Area of inner path (A) = $2d(l+b-2d)$
= 2×15 (150 cm + 105 cm - 2 x 15 cm)
= 30 cm (255 cm - 30 cm)
= 30 cm x 225 cm
= 6750 cm^2

3- Reflection

Mathematical problems can be solved in our local units according to our context in one hand, On the other hand, more than one method can be used to solve the single problem in mathematics.

4. View towards project work

Such activities in solving problem empower me to enrich the concept as well as to contextualize mathematics learning.

ANNEX - F

EVALUATION SHEET

Being together with my research participants, I have evaluated the outcomes of the project-based learning in my inquiry from different perspectives giving the following parameters in priority.

S. N.	Criterions of evaluation	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	Active participations					
2	Collections/Design and Creation					
3	Art Integration					
4	Assignments					
5	Project Works					
6	Works Presentation					
7	Critical Reflection					