

Practices of ICTs in Mathematics Classroom: Opportunities and Challenges

By

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Recommendation

I have read and recommended to the 'Faculty of Education ', Tribhuvan University for acceptance of the thesis entitled '**PRACTICES OF ICTS IN MATHEMATICS CLASSROOM: OPPORTUNITIES AND CHALLENGES**' submitted by **Ranadhir Kumar Sah** in the partial fulfillment of **MASTER OF PHILOSOPHY IN EDUCATION WITH SPECIALIZATION IN MATHEMATICS EDUCATION**.

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Approval Letter

The undersigned clarify that we have read, approved, and recommended to The 'Faculty of Education ', Tribhuvan University for acceptance entitled **'PRACTICES OF ICTS IN MATHEMATICS CLASSROOM: OPPORTUNITIES AND CHALLENGES'** submitted by **Ranadhir Kumar Sah** in the partial fulfillment of **MASTER OF PHILOSOPHY IN EDUCATION WITH SPECIALIZATION IN MATHEMATICS EDUCATION.**

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Ranadhir Kumar Sah

Abstract

My research was entitled "Practices of ICTs in mathematics classroom: Opportunities and Challenges." My research objectives were to explore the practices, opportunities, challenges, and way forward of ICT integration in mathematics classrooms. My research was qualitative with an ethnographic approach. Three schools having facilities of ICTs were my research site. My research samples were six mathematics teachers, six students, two head teachers, and two ICT experts whereas sampling was purposive. My data collection methods were in-depth interviews, participant observation, and focus group discussions.

Teachers and students are practicing ICTs by engaging, demonstrating, gaming, and using applications. Motivation to learn, availability of learning materials, student and teachers interaction, opportunities for self-learning, and the chance of teaching-learning and earning are the opportunities whereas insufficient infrastructures, lack of internet network, lack of willingness of admin, teachers insufficient knowledge, lack of teacher's training, lack of time, insufficient budget, lack of skillful manpower, digital divide, misuse of technologies, and high cost of ICTs' tools are challenges of ICT integration in the mathematics classroom. Developing ICT-friendly infrastructures, conducting effective teacher training, developing well-acceptable applications, redesigning the syllabus, minimizing the cost of ICT tools, and recruiting skillful manpower are the coping strategies for these challenges.

Teachers and students are practicing ICTs in mathematics classrooms by their choice but facing a lot of problems. To solve these problems this research would be the guideline for policymakers, curriculum designers, schools, teachers, and students to develop ICT-friendly plans, curricula, infrastructure, environment, and learning way.

Table of Contents

Copyright.....	i
Declaration	ii
Recommendation	iii
Approval Letter.....	iv
Acknowledgement.....	v
Abstract.....	vi
Table of Contents	vii
Acronyms.....	xiv
Chapter I.....	1
INTRODUCTION	1
Context of the Study	1
Fulfill the Fundamental Right and Ultimate Goal of Education.....	2
Education Review Office (ERO) Report	3
Recent Demand.....	4
Need of ICTs in Mathematics Classroom.....	5
Historical Development of Education and Place of Mathematics	6
History of Mathematics Teaching and Learning through Technology	8
Future of ICTs in Mathematics Classroom.....	9
Scarcity and Need of ICTs Literacy.....	10
ICTs and ZPD	12
Policy, Plan and Practice of ICTs in Mathematics Teaching and Learning	13

International Perspective.....	13
National Perspective	15
Mathematics for All (MFA) Through ICTs	17
Statement of the Problem.....	17
Rationale of the Study.....	20
Objectives of the Study.....	21
Research Questions	21
Delimitations of the Study	22
Definitions of Key Terms	23
Chapter II	24
LITERATURE REVIEW	24
Empirical Literature Review	24
Thematic Literature Review	32
Benefits of Virtual Learning.....	32
Online Classes and Students' Satisfaction	33
Barriers of Online Mathematics Teaching.....	34
E-learning Vs. Traditional Learning	34
Theoretical Review	35
Constructivism Theory.....	36
Theory of Connectivism	37
Technological Pedagogical Content Knowledge (TPACK) Model.....	38

Conceptual Framework.....	41
Implication of the Review for the Research	43
Gap Spotting	43
Chapter III.....	45
METHODOLOGY	45
Research Paradigm.....	45
Ontology	46
Epistemology	47
Axiology	47
Research Design.....	48
Qualitative Research with Ethnography Approach.....	49
Study Site	50
Sample and Sampling	51
Profile of Research Participants.....	52
Data Collection Methods and Tools	53
In-depth Interview.....	54
Participant Observation.....	55
Focus Group Discussion (FGD).....	56
Data Collection Procedure	57
Data Analysis Procedures	58
Transcribe	59

Translate.....	59
Coding.....	59
Theme Generating.....	59
Linking With Theories and Litratures.....	60
Quality Assurance.....	60
Credibility.....	60
Transferability.....	61
Dependability.....	61
Confirmability.....	62
Ethical Considerations.....	62
Chapter IV.....	64
ICTS' PRACTICES IN MATHEMATICS CLASSROOM.....	64
Students' Engagement.....	65
Demonstrating the Resources.....	72
Gamification of Learning Mathematics.....	78
Mathematics Learning by Apps.....	83
Teaching Mathematics during the Pandemic Covid-19.....	88
Chapter Summary.....	95
Chapter V.....	96
OPPORTUNITIES OF ICTS INTEGRATION IN MATHEMATICS	
CLASSROOM.....	96
Motivation to Learn Mathematics.....	96

Saving Time and Cost to Learn Mathematics	101
Availability of Finding Learning Materials	103
Students' and Teachers' Interaction	106
Opportunities of Self-learning	109
Student Friendly Environment in Classroom.....	111
Opportunity of Teaching, Learning and Earning	114
Chapter Summary	117
Chapter VI.....	118
CHALLENGES OF ICTS INTEGRATION IN MATHEMATICS	
CLASSROOMS	118
Insufficient Infrastructures in School.....	118
Lack of Internet Network.....	122
Lack of Willingness Administration toward the ICTs' Use	124
Teachers Insufficient Knowledge of ICTs	126
Lack of Teacher's Training of Using ICTs.....	129
Insufficient Time Period	131
Insufficient Budget for Managing Digital Technology	132
Lack of Skilful Manpower	134
Digital Divide.....	137
Misuse of Technologies	139
High Cost of ICTs' Tools	141
Chapter Summary	144

Chapter VII	145
COPING STRATEGIES OF CHALLENGES.....	145
Developing ICT Friendly Infrastructures.....	145
Conducting Effective Teacher Training for ICTs' Integration in Mathematics	
Teaching-learning	147
Developing Well Acceptable Apps.....	151
Redesigning the Syllabus	152
Minimizing the Cost of ICT Tools.....	154
Recruiting Skilful Manpowers	155
Chapter Summary	156
Chapter VIII.....	157
FINDINGS, CONCLUSIONS AND IMPLICATIONS.....	157
Findings.....	157
Conclusions.....	159
Implications.....	161
Implication for Teachers	161
Implication for Students.....	162
Implication for Schools.....	163
Policy Implications	163
Curriculum Implication.....	164
References.....	a
Appendix-I.....	A

Appendix-II	B
Appendix-III.....	C
Appendix-IV	D
Appendix-V.....	E
Appendix-VI.....	F

Acronyms

ACCR :	Acceptance, Confidence, Competent, and Resistance to Change
BECTA:	British Educational Communications and Technology Agency
BTT:	Bloom's Taxonomy Theory
ERO:	Education Review Office
F2F:	Face to Face
ICT:	Information and communication Technology
IIMC:	ICT Integrated Mathematics Classroom
IITL:	Technology Integration in Teaching and Learning
IITLP:	ICT Integrated teaching learning process
IT:	Information Technology
K-12:	Kindergarten to 12 th grade
MC:	Mathematics Classroom
MFA:	Mathematics for all
NCEB:	National Center for Educational Development
NCERT:	National Council of Educational Research and Training
NNF:	Nepal National Framework
NVQF :	National Vocational Qualification Framework
PPLC:	Paper Pencil less Classroom
STEM:	Science, technology, engineering and mathematics
TAM:	Technology Acceptance Model
TDT:	Transactional Distance Theory
TLO:	Teaching and Learning Observatory
TPACK:	Theory of Technological Pedagogical Content Knowledge
TPB:	Theory of Planed Behavior

TRA:	Theory of Reasoned Action
TU:	Trihuvan University
TVET:	Technical and Vocational Education Training
UNESCO:	United Nations Educational, Scientific and Cultural Organization
UTAUT:	Unified theory of Acceptance and Use of Technology
VLE:	Virtual Learning Environment
ZPD:	Zone of Proximal Development

Chapter I

INTRODUCTION

Context of the Study

The research context provides context for interpreting the study or method, reasons, findings, conclusions, and recommendations (Given, 2008). Context is crucial because it helps researchers to appreciate the complexity and diverse diversity (Given, 2008) of the phenomena they are investigating and how they relate to the different social actors and institutions.

I am a secondary-level mathematics teacher. I have been teaching mathematics for more than ten years. I observed, students are feeling unhappy in mathematics classrooms and getting very low marks in mathematics examinations. Headteachers, other teachers, parents, and students always complain about mathematics teaching. In this context, I felt the need for improvement in the teaching pedagogy.

Since some mathematics teachers were teaching mathematics through information and communication technologies (ICTs) and I was also very interested in using ICTs, one question raised in my mind was that "Is it better to teach mathematics through ICTs?" In this context, I needed research to find how teachers were using ICTs in the mathematics classroom. What were the opportunities and challenges of teaching mathematics through ICTs? How teachers were coping those challenges? To answer these questions, I carried out research entitled "Practices of ICTs in the mathematics classroom: Opportunities and Challenges."

Even though teachers are teaching with great effort, only a low percent of students get acceptable achievement in mathematics (Education Review office [ERO], 2019). So, the other context of my study was to fulfill the fundamental right and goal of education, the education review office (ERO) report, and recent demand.

Fulfill the Fundamental Right and Ultimate Goal of Education

Education has been constituted as fundamental right of people (Constitution of Nepal, 2015). The ultimate aim of education in Nepal is to educate individuals with the necessary information, skills, and attitudes to actively participate in the country's development and to integrate Nepal into the global community by providing equitable access and quality of education for everyone (School Sector Development Plan [SSDP], 2016). Use of Information and communication technologies (ICTs) may be milestone to execute the fundamental right of education and get the ultimate goal of education.

To achieve the ultimate aim of education, the Ministry of Education believes the use of ICTs is essential. As a result, the Ministry of Education intends to educate students with ICTs skills and to use ICTs as a significant instrument to improve classroom delivery and increase access to learning resources. Ministry of Education (2013) developed and executed a master plan with vision "...to ensure extensive use of ICTs in education sector and contribute for access to and quality of education for all" (Information and Communication Technology [ICT] in Education Master Plan, 2013-2017).

School sector development plan [SSDP] (2016) has strengthened ICTs' infrastructures. ICTs enabled teaching learning for Science, Mathematics, and English (School sector development plan [SSDP], 2016). National Centre for Educational Development [NCED] (2005) has carried out various teachers training to enhance the teachers' capabilities of ICTs so that they can use it in teaching learning.

In this context I intended to know that whether teachers and students are using ICTs in teaching learning? How are teachers and students integrating ICTs in mathematics classroom? What are the challenges of ICTs integration in mathematics

classroom? How those challenges can be addressed? To answer these questions I were motivated to carry out a research entitled practices of ICTs in mathematics classroom: opportunities and challenges.

Education Review Office (ERO) Report

Students are not getting satisfactory achievement in mathematics (Education Review Office [ERO], 2019). Even teachers are teaching with great effort only few percent of students get acceptable achievement in mathematics. ERO (2019) studied entitled “National Assessment of Students achievement 2018: Main Report” with the objective to identify the current level of grade 5 students’ achievement in mathematics. The research found only 28% of the students has adequate knowledge and skill in mathematics curriculum. Mathematics teachers are teaching in traditional ways. There is a lack of understanding of mathematical concepts for students. The result of mathematics is not satisfactory for a long time. Unsatisfactory result in mathematics has been an issue for a long time because it attributed to the increasing failures in the SLC examination (ERO, 2020). Why there is an unsatisfactory result in mathematics? Why only few present students have adequate knowledge and skill in mathematics curriculum? This may be because of inadequate teaching learning method and tools. This problem may be solved by using ICTs.

I thought teaching through ICTs may be better solution for those problems. The better understanding and creative learning of mathematics makes a student’s better achievement. Teaching through ICTs can create opportunities for students and teachers for better learning environment. This will lead us to better achievement in mathematics. So ICTs integration in mathematics classroom is very necessary. I was curious to know the answers of the questions such as are teachers using ICTs in mathematics classroom? How are they using ICTs in mathematics class room? What

are the problems of ICTs integration in mathematics classroom? How those problems can be solved? So, it was urgent to study entitled practices of ICTs in mathematics classroom: opportunities and challenges.

Recent Demand

This is the age of Information and communication technologies (ICTs). Most of the teachers and students are supposed to have ICT tools like android mobile phone, laptop, computer, tablet etc. In my opinion they are using ICT tools to play games, enjoy face book, watch You Tube videos etc. Sometimes they use ICT tools in learning subjects like Social, Health Population and Environment, English, Nepali, Science, and Mathematics. They seem very positive toward using ICTs in mathematics classroom. Furthermore due to covid-19 (pandemic) everyone seems to be arrested in their home. Due to this pandemic physical classes are banded. So, I think virtual class may be the best option for teaching and learning. Furthermore as demand of society and time every subjects are being taught through ICTs.

Mathematics teachers are teaching mathematics through ICTs even they don't have proper tools and knowledge. The interesting fact is that even teachers are learning ICTs from students. Even teachers attend various ICTs training they have lack of proper knowledge in ICTs. Students are learning both mathematics and ICTs together. Students are facing a lots of problems related to ICTs integration in mathematics classroom. In spite of multiple barriers use of ICTs in mathematics classroom is in progress. I was motivated to explore the issues and challenges of ICTs integration in mathematics classroom. I was excited to know how teaching learning process is developing in mathematics classroom. How teachers and students are facing the barriers? These questions lead me to the research on practices of ICTs in mathematics classroom: opportunities and challenges.

Need of ICTs in Mathematics Classroom

It is said that mathematics has given birth to ICTs. Now it's time to use ICTs in mathematics learning. According to Scharaldi (2020) in mathematics classrooms, technology offers exciting new ways to teach. Through engaging and interactive media, we can improve the learning process and bring concepts to life. Furthermore Scharaldi (2020) adds additional assistance may be provided to meet the requirements of all learners and to provide customized learning experiences. When we use technology into our mathematics and science, technology, engineering and mathematics (STEM) lesson instruction, children can be benefited in a number of ways.

The world is changing day by day. Revolution in technologies has accelerated the changing rate of human behavior. Almost every fields of the profession are renewing itself. Nowadays every subject area is using information technology (IT). Information technology (IT) is the use of computers to create, use, store, exchange, and interoperate electronic data whereas ICT is the bloomed form of IT. ICT is the technology whicthat perform more than IT with wireless technology. ICT refers to technology that gives information access via telecommunications. It is comparable to IT, however, it is mostly concerned with communication technology. The Internet, wireless networks, cell phones, and other communication channels are all examples of this (Christensson, 2010). Information technology is defined as a scientific, technical, and engineering discipline and management approach utilized in the handling of information, its application,n and its relationship with social, economic, and cultural concerns (United Nations Educational, Scientific, and Cultural Organization [UNESCO], 2002). According to Blurton (2002), ICTs stand for information and communication technologies and are defined as a "diverse set of technological tools

and devices used to communicate, as well as create, distribute, store, and manage information. Prytherch (2000) explains ICTs are networks that enable new options for teaching, learning, and training through digital content delivery. ICT tools contain different forms of technology. The area of ICT tools is getting wider and wider gradually. The reason behind this is that the rapid innovations in technology. Desktop, laptops, mobiles, notebooks, tablets, digital cameras, internet, browsers, drives, cloud computing, pen drive, memories, Bluetooth, virtual environment, team, zoom, Google Class, and virtual environment are some examples of ICT tools. Many ICT tools are developed.

Some of the teachers are using those ICTs tools in mathematics classroom. My aim is to find out how they are using ICTs in mathematics classroom? What are the barriers of integrating ICTs in mathematics classroom? How those barriers can be removed?

Historical Development of Education and Place of Mathematics

Nepal started teaching through Gurukul education and home learning. Education was based on religious especially on Sanskrit and Buddhist. Education system was based on cast system in sanatan religious. For example, only Brahmans and Kshetries were eligible for education. Ved, Upanishad, Bhagavad Gita, Mahabharata, Ramayana, and other holy books were sources of education. Brahmans used to study science of rituals whereas kshetries used to study about administration and war fare. Buddhists used to study Tripitaka (Vinaya Pitaka, Sutta Pitaka, and Abhidhamma Pitaka) and Sutras in Gumbas.

There was Ranas dynasty from 1846 to 1951 in Nepal. A modern education system was introduced in this period. In 1954 Jung Bahadur Rana introduces English education in Nepal. It was for Ranas and people related to Ranas specially elites. Dev

Samser Rana allowed it for public in 1990. School Leaving Certificate examination was affiliated by the University of Calcutta till 1934. In 1951 democracy was established in Nepal. From this period government of Nepal tried to expand the education opportunities so that most of the people can get better education. Till 1950 the literacy rate of Nepal (above 15 years old) was 5% only. Now the literacy rate of Nepal (above 15 years) is 67.9% and it is growing rapidly.

Constitution of Nepal (2015) has introduced education as fundamental right. Right to education falls under the fundamental rights and duties of part 3. Article 31 of constitution of Nepal has elaborated the right to education. According to Constitution of Nepal (2015) every citizen shall have the right of access to basic education, every citizen shall have the right to get compulsory and free education up to the basic level and free education up to the secondary level from the state, the citizens with disabilities and the economically indigent citizens shall have the right to get free higher education in accordance with law, the visually impaired citizens shall have the right to get free education through brail script and the citizens with hearing or speaking impairment, to get free education through sign language, in accordance with law, every Nepalese community residing in Nepal shall have the right to get education in its mother tongue and, for that purpose, to open and operate schools and educational institutes, in accordance with law. This encourages the large number of people to study and objective of Nepal government is to make 100% literacy.

Mathematics is the core subject of school curriculum. Mathematics learning has a long history. Mathematics plays vital role in our daily life as well as in technologies and super technologies. We can say that mathematics begins from counting number and now a day it is being used in the study of space science. About each factors of country is affected by mathematics. Social, economic, technologies,

medical, engineering, trades, foreign affairs are driven through mathematics calculation. Mathematics is the study of measurements, numbers, and space, and it was one of the first disciplines developed by humans due to its importance and value (The Scientific World, 2021). There are various fields of mathematics that are related to numbers, geometric shapes, algebra, and others. The word mathematics comes from Greek which means tendencies to learn (The Scientific World, 2021). Mathematics is used in almost every field of life, including everyday tasks like timekeeping, driving, and cooking, as well as professions like accounting, finance, banking, engineering, and software development. These functions require a solid mathematical foundation, and scientific experiments by scientists necessitate the use of mathematics. In fact education has a long history and mathematics has always embedded with education.

History of Mathematics Teaching and Learning through Technology

In mathematics education, the use of technology has a long history. Using fingers in addition, subtraction, multiplication, division, even and odd number is a better example of use of ICTs in mathematics teaching learning. Children first develop ideas concretely and then progress towards abstractions (Piaget, 1970). After that teachers started to teach abacus arithmetic. Abacus facilitates computing. It provides a visual representation of mathematics, which aids in learning. Students are able to comprehend complicated topics. Computation and illustration pass hand-in-hand, each traditionally and with inside the present. For example, in number of college classrooms, many instructors use concrete manipulative, such as Geoboards (permitting kids to make geometric figures with the aid of using stretching rubber bands over a grid of nails) or Diane's Blocks (imparting kids with a bodily version of the place-price machine in which "473" manner 4 hundreds, seven tens and three

ones) to teach mathematics.

In secondary schools, researchers have determined that extra superior gears are necessary. These superior gear assist college students learn with the aid of using assisting computation and with the aid of using giving summary thoughts an extra tangible shape. Researchers have determined that while bodily manipulative are the proper tangible shape for essential college, ICTs-primarily based totally gear are the proper tangible shape for secondary college (Kaput, 1992). Researchers have found that ICTs can support learning when properly integrated into teaching techniques, programs and assessments (Means & Haertel, 2004). Therefore, for more specific guidance, teachers should seek research on the integrated use of ICTs in mathematics education. In this research we discuss two elements of successful integrations in brief: focus the student and teacher thinking or producing tangible ideas.

ICT integration in teaching-learning has a moderate history but for Nepal it is new. So, I intended to know how our teachers using ICTs in mathematics teaching-learning. How are they managing the barriers of ICTs' integration in mathematics classroom?

Future of ICTs in Mathematics Classroom

Paper pencil less classroom (PPLC) is being promoted. Many company and institutions are investing in distance mode learning. It is because teaching and learning through ICTs have bright future. An effective learning through ICTs product built using instructional design best practices can assist a corporation in achieving a successful learning process, thereby educational companies and institutions invests in distance learning. TU has also started MPhil Programs through ICTs. Professors say students prefer learning through ICTs rather than physical classes in MPhil. It is because learning through ICTs saves time and money. Natural disasters, pandemic

and other physical barriers (like distance) can't affect classes through ICTs. Many companies and governments are investing a large amount of money in the field of research in ICTs. Of course, the importance of the face to face (F2F) instruction method cannot be reduced, but e-learning can be used together with the traditional methods to bring in efficiency, effectiveness, and competitive edge over other competitors by imparting quality education (Barboni, 2019). That's why we can easily guess that teaching and learning through ICTs has a brilliant future and those who don't want to cope with ICTs will be vanished.

Many researches showed that ICTs in mathematics education has a brilliant future. But at present, I wanted to know how our teachers and students are thinking about ICTs or learning mathematics through ICTs? How are they integrating in mathematics teaching and learning with ICTs? How are they enjoying the benefits of ICTs and facing the barriers? How their perception is changing toward mathematics learning through ICTs? How are they practicing mathematics through ICTs? These questions provoked me to carry out a research entitled practices of ICTs in mathematics classroom: opportunities and challenges.

Scarcity and Need of ICTs Literacy

Because of the explosion of ICTs knowledge and its integration in daily life, it is being compulsory for everyone to learn and use ICTs. Students who have knowledge of ICTs have better future because there is high scarcity of ICTs literate persons in society and demand of such persons is increasing day by day. In mathematics teaching and learning we can say that only few teachers have caliber to teach mathematics through ICTs fluently but the demand of ICT integrated mathematics teaching learning increasing gradually. We can find a lots of mathematics knowledge in the box of internet. Students and teachers can understand

mathematics concepts through ICTs. The connectivism theory stated that knowing where to get knowledge is essential. ICTs provides the place where we can get knowledge. We can say that persons who don't have ICTs knowledge will face a lot of problems in understanding the concepts or solving problems. "Teaching ICTs skills in elementary schools prepares students to face future developments on the basis of correct understanding" (Grimus, 2000).

Mathematics Teachers who have scarcity of knowledge of ICTs seems to be disappeared in coming future because the demand of society is increasing in learning mathematics through ICTs. Classroom is essential to provide students with opportunities to learn to work in an information age. Yelland (2001) argued that traditional educational settings do not seem adequate to prepare learners to function or be productive in the workplaces of today's society. Organizations that do not consider the use of new technology in schools cannot seriously claim that they prepare their students for life in the 21st century (Yelland, 2001). "What is known today about learning provides important guidelines for the use of technology that can help students and teachers develop the skills needed for the 21st century" (Bransford et al., 2000). ICTs can play various roles in the teaching learning processes of mathematics. Including ICTS in teaching learning process it helps not only students but teachers also in getting, manipulating and generating knowledge. Several studies reviewed the literature on ICTs and learning and concluded that they have great potential to improve student performance and teaching (Bransford et al., 2000). Wong et al. (2006), suggested that technology may play a role in facilitating teaching and personal learning in the classroom. Many researchers and theorists claim that the use of ICTs can help students to acquire knowledge, reduce the number of direct instruction and allow the teachers to serve students (Shamatha, Peressini & Meymaris, 2004; Romeo,

2006). While new technologies can help teachers improve their teaching practice, they can also help students learn. According to (Grabe & Grabe, 2007) technologies can play a role in students' skills, motivation and knowledge. They claim that ICTs can be used to present information to students and help them complete many study assignments. According to Becta (2003) five factors influence the probability that good ICTs learning opportunities will develop in schools: ICTs resources, ICTs leadership, ICTs teaching, school management and teaching general. Becta (2003) also pointed out that the success of integrating new technology into education varies from one curriculum to another, from place to place and from class to class, depending on how it is applied in. It is clear that IIMC has bright future. So there is need of research entitled practices of ICTs in mathematics classroom: opportunities and challenges.

ICTs and ZPD

ICTs can provide the better opportunities to the teachers and students in teaching learning process. Many applications in ICTs can provide the better opportunities to get practice mathematics knowledge. For sharp students, ICTs can give the opportunities to enhance their mathematics knowledge. It can be better equipment to fulfill the Zone of proximal development (ZPD). Effective interactive learning and student center teaching can be conducted through ICT integrated mathematics classroom. These two things can fulfill the extra demand of students and fill the ZPD. So I wanted to know how our teachers and students are using ICTs in mathematics classroom. What are the problems of ICTs integration in mathematics classroom? How those problems can be solved? These questions encouraged me to the research entitled practices of ICTs in mathematics classroom: opportunities and challenges.

Policy, Plan and Practice of ICTs in Mathematics Teaching and Learning

Practice of ICTs in mathematics classroom is increasing rapidly. ICTs in mathematics teaching and learning is being emphasized in all over the world. We can explain this from international and national perspective.

International Perspective

Department of education of United States of America has developed plans to integrate ICTs in teaching learning. The main plan is National Education Technology Plan (NETP). NETP (2021), included educational technology breakthroughs and present a vision for how schools insert ICTs around the country can continue to employ technology to increase fairness and opportunity for all students and will also address infrastructural requirements to make the vision a reality. The NETP (2017), established a national vision and plan for technology-enabled schooling by drawing on the expertise of top education researchers, ICTs, school, and higher education officials, classroom teachers, developers, entrepreneurs, and voluntary organizations (U.S. Depart of education, 2017). NETP (2016), provides a vision of how technology may revolutionize formal and informal learning, emphasizing key factors such as trained teachers and staff, high-quality curriculum and materials, strong leadership, solid infrastructure, and aligned assessments (U.S. Depart of Education, 2017).

India has launched a policy to enhance integration of ICTs in school education which has mathematics as a core subject. The vision of the ICTs Policy in School Education is to prepare students to engage creatively in the construction, maintenance, and expansion of knowledge in society, which will lead to the nation's overall socioeconomic development and worldwide competitiveness where the mission is creating, catalyzing, supporting, and sustaining ICTs and ICTS-enabled activities and procedures to increase access, quality, and efficiency in the education system

(Department of School Education and Literacy Ministry of Human Resource Development, Government of India, 2012). Policy objectives of Department of School Education and Literacy Ministry of Human Resource Development, Government of India (2012) are strive to: provide environment favourable to the development of an ICTs-literate community capable of deploying, utilizing, and benefiting from ICTs and contributing to nation building, an environment conducive to the formation of a demand for optimal utilization of and returns on the potentials of ICTs in education. Finally, policy would encourage and facilitate broader engagement of all segments of society in enhancing the school education process through proper use of ICTs (Department of School Education and Literacy, Ministry of Human Resource Development Government of India, 2012).

Denmark has a technology in education action plan, and a new strategy concentrating on development of digital education. Andalusia, Canarias, Extremadura, Galicia, and Navarra are some autonomous communities who have established their own digital education initiatives in Spain. In Croatia there is a wider strategy and a particular strategy on digital maturity of schools and the education system had been devised and implemented. This followed the completion of the e-Schools pilot project, which developed a mechanism for establishing digitally mature schools in 2018 (Eurydice, 2019). In Cyprus, the Pedagogical Institute is in charge of teachers' continuous professional development, including digital education. The institution also maintains a variety of online portals to assist schools and instructors, some of which include digital learning resources and tools for assessing students' abilities (Eurydice, 2019). A 'Programme Board' meets quarterly in the United Kingdom (Scotland) to discuss progress on, and barriers to, strategic initiatives of implementation of ICTS in education. Furthermore, Education in Scotland is in charge of tracking progress

toward actions and targets (Eurydice, 2019). In Montenegro, the Ministry of Education produces an action plan for implementing the measures outlined in the strategy which are related to use of ICTS in education at the start of each year, and the Ministry reports back to the Government at the conclusion of the year (Eurydice, 2019). This has enabled certain focused advancements in the field of digital education. These countries mentioned above have special focus on mathematics. They all have integrated mathematics teaching and learning in their policy and plan (Eurydice, 2019).

National Perspective

The Ministry of Education (MoE) began the radio education teacher training project in 1978 with technical and financial assistance from USAID. According to Dahal (2014), audio broadcasting began in 1980 with the goal of increasing the professional capacities of in-service elementary teachers with School Leaving Certificate (SLC). In 1994, the Ministry of Education established the Distance Education Centre (DEC). Through radio transmission, the center provided teacher training and education awareness activities. Following the merger of DEC and the National Centre for Education Development (NCED) in 2005, professional development training courses for elementary through secondary teachers, SLC assistance, and education information radio programs are now offered (Dahal, 2014).

Ministry of Education of Nepal (MoE) have launched a master plan information and communication technology (ICTs) in education. The vision and mission of the plan was to guarantee widespread use of ICTs in the education sector, hence improving access to and quality of education for all and narrow down the digital divide through the development of ICTs infrastructures, human resources, digital contents and system enhancement in education (MoE, 2017). To increase equal

access to education, improve educational quality, narrow the technology gap, and strengthen the educational service delivery system were the goals of master plan (MoE, 2017).

The Nepalese government has implemented a program to boost technical and vocational education. The strategic approach to expanding school-based technical and vocational education training (TVET), emphasizing the relationship between the school curriculum and the world of work and skills, developing soft skills, and using ICTS are important initiatives expected to achieve the sustainable development goal (SDG) objectives (Nepal National framework [NNF], 2019) . Another plan of NNF (2019) is policy intervention in TVET that is being explored is the provision of assuring lateral mobility from general to vocational streams and vice versa via the national vocational qualification framework (NVQF).

Department of information technology of government is running online classes and releasing videos of teaching learning of various subjects including mathematics. National centre for educational development (NCED) is running teachers and head teachers training. For teachers training NCED emphasizes on ICT integrated classroom and in head teachers training NCED discusses on the barriers and opportunities of ICTs as pedagogical tool.

According to Pageni (2016), certain schools, colleges, and universities also provide scheduling flexibility: evening, day, or early classes. Students who are too busy during the day can attend morning or evening sessions, depending on their preferences. According to Dhakal (2021), Tribhuvan University (TU) and Kathmandu University (KU) are two universities of Nepal who have launched Bachelors and the Masters level through distance and online mode. The Open and Distance Learning (ODL) programs of these two universities are for teacher education (Dhakal, 2021).

Each entity of MoE of Nepal are focusing on the integration of ICTs in teaching learning. They are investing on the infrastructure related to ICTs and on teachers training. They are also promoting the ICTs related on the materials and trying to pedagogical transformation from traditional to ICT integrated classroom. This catalyzed me to carry out the research entitled practice of ICTs integration in mathematics classroom.

Mathematics for All (MFA) Through ICTs

MFA stands for mathematics for all. Which is a program with aim to increase mathematical literacy. According to UNESCO (2014), ICTs in education has a multiplier effect throughout the education system by improving learning and providing students with new skills; reaching students who have limited or no access (particularly those in rural and remote areas); facilitating and improving teacher training; and reducing costs associated with traditional instruction. Use of ICTs reduces the obstacles and cost of learning mathematics which leads to get MFA.

Statement of the Problem

ICTs make life easier. We can say 21st century is era of ICTs. There is explosion in development of ICTs. Every field is coping with ICTs. The main means of teaching learning is communication i.e. ICT provides better communication to use of ICTs in teaching-learning has been raised. Wireless technologies have filled the physical gap between teacher and student. Now a student from one remote area can easily access to better school or university. This all has become possible due to development in ICTs. The value and use of ICTs always climb up in natural disaster and pandemics. Since we are fighting with Covid -19 (pandemic) so the value and use of ICTs in teaching learning has been raised. Almost each and every teacher wants to teach through laptop, mobile, desktop, tablets and other ICT devices. They have

content and pedagogical knowledge and they also have technical knowledge to some extent. Students also want to study through use of ICTs. Teachers and students can construct knowledge if they use ICTs in mathematics classroom. They can connect their knowledge in both horizontal and vertical ways within the mathematics content. They can connect their knowledge with other subjects and develop knowledge. The demand of internet has been maximized and use of data has been optimized. But only few teachers are using ICTs in mathematics classroom. I want to investigate, why only few teachers and students are using ICTs in mathematics classroom? Why has it been a challenge to use ICTs in mathematics classroom? How teachers and students are facing obstacles while using ICTs in mathematics classroom? So, there is need to carryout study entitled on practices of ICTs in mathematics classroom: opportunities and challenges.

Most of the local levels are encouraging teacher's training through ICTs. It seems that main demand of teachers is to learn how to use ICTs in teaching in their subject. I realized that Mathematics teachers also want to teach by using ICT tools. So to fulfill this demand, many teachers professional development (TPD) training involves the training of GeoGebra and other apps. Many mathematics teachers have participated in ICTs training. Now I want to know how teachers are preparing their lesson plans including ICTs. How are they presenting themselves in mathematics classroom? How are they preparing for teaching? How are they checking home works? How are they connecting the knowledge? How are they presenting the lessons in classroom? To find answers of above questions, I am motivated to study on practices of ICTs in mathematics classroom: opportunities and challenges.

On the other hand, students are being familiar with ICT tools day by day. We can say that students are learning in ICTs every day. They seem to be very interested

to use of ICTs. Each student is able to use social Medias like Facebook, Whatsapp, viber, messenger and other social media platforms. They can easily open You Tube and other apps. Some of the students play various types of games in mobile or other ICT tools. Use of ICTs in teaching learning mathematics is being familiar. Students are using ICTs in mathematics learning at some extent. In this context, my desire is to explore how students are learning and practicing mathematics through ICTs? How do they connect their problem to other contents? How are they creating new knowledge and presenting in class through ICTs? How do they get feedback? How learning through ICTs is making them creative? To answer these questions I am motivated to carry out a research entitled practices of ICTs in mathematics classroom: opportunities and challenges.

Connectivism theory focus on practical knowledge and emphasize on the question where to get knowledge rather than when and how to get it. But in classroom teachers focus on tradition ways of teaching learning. Most of the teachers focus on rote learning rather than practical approach of teaching. If one question is raised in classroom teachers and students focus on the ways of solving and many teachers solve the problem on board. Only few teachers say where they can find it's answer. ICT integrated mathematics classroom can provide the knowledge that where knowledge can be found. Constructivism theory emphasis on interactive learning and student cantered teaching. It focuses to fulfil the of ZPD students. But in our practice of traditional teaching learning method is emphasized. The teaching is teacher centered and there is only few practice of interactive learning. ICT integrated mathematics classroom can provide the opportunities of interective learning, student center teaching and fulfil the ZPD of students. TPACK theory states that teachers having three types of knowledge are best of teaching in this modern age. Teachers who have

content knowledge, pedagogical knowledge, and technical knowledge can teach smartly. But in the context of Nepal only few teachers have all three types of knowledge.

Many researches have pointed out the problems or barriers of IIMC. While I studied some articles and thesis I came to know that teachers and students are facing a lot of problems. Problems of tools, time, attitude, and training are some representative. This study clarified that those problems are also the problem of my research area or other problems are there. My study will also find why are these problems raised? How are teachers and students facing these problems? How these problems can be managed?

Rationale of the Study

ICTs in education have multiple effects throughout the education system by improving learning and providing students with new skills; reaching students who have limited or no access (particularly those in rural and remote areas); facilitating and improving teacher training; and reducing costs associated with traditional instruction (UNESCO, 2014). My study helps the Government, policy makers, administrations, teachers and students to understand the need of ICTs in mathematics teaching and learning. This research provides better information to the curriculum designer so they can design ICT friendly mathematics curriculum. It helps government and trainers to understand the real ICTs need of mathematics teachers so they can train mathematics teachers in ICTs related to mathematics teaching. This research enlightens the practice of ICTs in mathematics classroom. I exposes the ways in which teachers are using ICTs to prepare lesson plan, prepare for teaching, present in classroom, and connect it to other discipline. My study helps them to refinement on practice of ICTs in MC. This thesis ascertained the way in which students are using

ICTs in mathematics learning. This found the ways in which students are learning mathematics, solving the problem, searching for new knowledge and connecting with other field. This investigation would provide them to use ICTs in better way for practice in classroom. This research would brought out the mathematics teachers barriers in using ICT tools and teaching mathematics through ICTs and identify the better ways to cop those problems so my research would help mathematics teachers to clarify their problems and get better solution. This study would help the students to express their obstacles in using ICTs in mathematics classroom and provide better solutions. This research would help to improve achievement of students in mathematics which seems very low. My research is initial and powerful point of transmissions of traditional teaching learning process to IITLP.

Objectives of the Study

1. To explore the practices of ICTs in mathematics classroom.
2. To explore the opportunities created by ICT integration in mathematics classroom.
3. To investigate challenges of ICTs integration in mathematics classroom.

Research Questions

1. How do teachers and students practice ICTs in mathematics classroom?
2. What are the opportunities created by ICTs integration in mathematics classroom?
3. What are the challenges of ICTs integration in mathematics classroom?
4. How the challenges of ICTs integration in mathematics classroom can be addressed?

Delimitations of the Study

I am a student of MPhil and secondary level mathematics teacher as well. Since I am on duty teacher I have to teach my students as well but my income is not sufficient. So, I have lack of time and money. Due to the lack of time and shortage of money I delimited my research to Kathmandu metropolitan. My research was delimited to mathematics teachers and students of secondary level. I collected my data from teachers and students of Kathmandu district having ICTs only. I included only the mathematics teachers and students of three government school. I preferred face to face (F2F) interections. I recorded the raw data in my mobile.

Definitions of Key Terms

ICTs. Information Communication and Technology applicable in mathematics teaching learning.

Classroom. Both physical and online classroom where teaching learning process take place.

Practice of ICTs. The ways in which teacher or student or both using ICTs in teaching-learning.

Opportunity. Opportunities created by ICTs in mathematics classroom.

Challenges. Challenges, barriers, problems, or obstacles of ICTs integration in mathematics teaching learning.

Coping strategy. Way forward for the challenges.

Chapter II

LITERATURE REVIEW

A Literature Review is a systematic, explicit, and reproducible method for identifying, evaluating, and synthesizing the existing body of completed and recorded work produced by researchers, scholars, and practitioners (Fink, 2005). Reviewing the relevant literature is an important part of study for the investigator. Related literature review assists and guides the researcher in adhering to the study the objective of the research. A brief summary of previous research and thus the writings of recognized experts shows that the researcher is used to what is already known, and what is still unknown and unproven. Literature review helps for gap sporting between the previous researches and new demand as well. It prevents duplication of work and provides useful hypotheses and useful suggestions for meaningful research. Literature reviews are often helpful to save time and energy. By understanding a literature search, we can critically summarize this information in the world under researches and identify strengths and weaknesses in previous work. By reading many different studies, we get an idea of conceptual framework. In this chapter, I included empirical literature review, theoretical literature review, conceptual framework, and implication of literature review.

Empirical Literature Review

An empirical literature review is also known as a systematic literature review. Through empirical literature review researchers reviews previous empirical studies to address a specific research issue. For my research I reviewed some articles, and thises which are related to my objectives.

Dhakal (2021) carried out a research entitled 'Learners' Experiences on Virtual Environment in Mathematics - A Case of Nepal Open University' to explore

he perception of learners towards virtual learning environment and the challenges that they faced in learning mathematics through virtual mode in the context of Nepal. This was a qualitative case study. This study was guided by the theory of connectivism. Focus group discussion and in-depth interviews were the tools by which data were collected. The findings indicated that using a virtual learning environment to improve knowledge, skills, and opportunities through resource search and networking is beneficial; however the major challenges for virtual learning are lack of digital infrastructure; pedagogical, technological, environmental, psychological, and content-based obstacles; and time management.

Keong, Horani, and Daniel (2006) published "A Study on the Use of ICTs in Mathematics Teaching." The research's major goals were to assist mathematics instructors in incorporating ICTs into their instruction and to investigate how teachers used the internet. Other goals included analyzing teachers' training needs, assessing the degree of ICTs usage instructional programs, determining the hurdles experienced by instructors during ICTs integration in mathematics courses, and investigating teachers' perceptions of the utility of an e-portal. The survey method was used for the research. The study concluded that the use of ICTs in mathematics instruction can improve the effectiveness of the teaching process as well as students' skills to grasp basic ideas. However, adopting its use in the classroom is fraught with difficulties due to the various hurdles that may develop. The study identified the various sorts of obstacles. As part of the ongoing research effort, a suggested e-portal to circumvent some of these hurdles was developed.

Das (2019) carried out a research entitled "Role of ICT for Better Mathematics Teaching". The primary goal of this research was to investigate the use of ICTs technologies in mathematics education. Other objectives were to investigate the

attitudes of mathematics instructors, mathematical background teachers, teachers from diverse backgrounds, to investigate classroom instruction with a mix of mathematics and ICTs, and to learn about the use of ICTs in teaching and learning at a teacher training institution. This study used an interpretive method. Research approach is based on document-based analysis. Qualitative data were gathered from research articles of journals, books, edited volumes, report and other internet materials. This study demonstrated the importance of ICTs integration in mathematics. Several issues regarding the use of ICTs in mathematics were identified in the literature. ICTs integration in mathematics education benefits both the teaching and learning processes. The study was carried out to identify the barriers to the integration of ICTs in mathematics teaching and learning at the Teacher-Training College and secondary school levels. There are certain challenges to integrating ICTs in mathematics teaching and learning in many disciplines of mathematics.

Colye (2004) carried out research entitled “Redefining Classroom Boundaries Learning to Teach Using New Technologies”. The study's goal was to look at how a technology breakthrough like the teaching and learning observatory (TLO) may be used to alter classroom boundaries. The longitudinal research approach was utilized to conduct the study. The TLO used video conferencing and interactive internet technologies to connect a network of somewhat rural schools with a university education department. After two years, the TLO network has shown to be an effective instrument for bringing together school students, teachers, mentors, teacher educators, and researchers. In dynamic learning communities, the technology allowed engagement in a variety of situations. TLO enhanced the ability of teachers.

Dhakal, and Sharma (2016) carried out a research entitled “Virtual Learning Environment (VLE) in Mathematics Education”. The objective of the study was to

make a critical note of the key opportunities and challenges the teacher / students experienced while using the VLE. This was an experimental case study, part of a longitudinal study at CDED. Merge e-pedagogy with the conventional mode, starting with less conventional e-pedagogy and then increasing the scope of e-pedagogy and reducing the conventional one. The VLE as a case was introduced into the teaching of Projective Geometry among 36, students of the Master of Education (Mathematics). The tool used in this study was the initial and final questionnaires, observation, checklist, interview guide, and file analysis found more interactive in learning through emotional, social and cognitive participation of VLE. Among various activities and resources in model such as VLE, the questionnaire was an effective activity and videos as the most preferred resource for students of all grades was quick and easy. Viewing students' personal computing devices, internet connectivity, and teachers' efficiency in using ICT tools, maximizing the teachers' presence in assisting learning, was identified as major challenges in using VLE. Despite the challenges, the main opportunities VLE brought to F2F classes were to improve study habits, make learning more active, provide opportunities for learning and relearning, and clarify concepts. It follows that F2F courses must be designed in an appropriate manner, taking VLE into account.

Abuhassna & et.al. (2020) carried out a research entitled development of a new model on utilizing online learning platforms to improve students' academic achievements and satisfaction. The aim of the research was to discover and examine the potential factors that influence academic performance and student satisfaction with the use of online learning platforms in higher education. This research used a quantitative research method. The model in this study illustrates eleven factors about the use of online learning platforms to improve academic performance and student

satisfaction. The results showed that student background, experience, collaboration, interactions, and autonomy positively influenced student satisfaction; the effects of application, remembering, understanding, analysis, and student satisfaction were positively matched on student academic performance. , empirical results show strong support for the integrative link between DTT and BTT theories regarding the use of online learning platforms to improve academic performance and student satisfaction that help decision-makers in universities and colleges to plan, evaluate and implement online could use learning platforms in their facilities.

Bingimalas (2009) presented an article entitle “Barriers to the Successful Integration of ICTs in Teaching and Learning Environment: A Review of Literature”. This paper offers a meta-evaluation of the relevant literature that target to give the perceived limitations to generation integration in technology education. This take a look at appears to be qualitative. Many articles, Books, thesis, and reviews had been analyzed on this take a look at. The findings suggest that instructors had a study preference for to combine ICTs into education; however that, they encountered many limitations. The most important limitations had been loss of confidence, loss of competence, and absence of get admission to assets. Since confidence, competence and accessibility had been observed to be the crucial additives of generation integration in schools, ICTs assets along with software program and hardware, powerful expert development, enough time, and technical aid want to be supplied to instructors. No one thing in itself is enough to offer excellent coaching. However, the presence of all additives will increase the opportunity of fantastic integration of ICTs in studying and coaching opportunities. Generally, this paper offers facts and advice to the ones accountable for the combination of latest technology into technology education.

Gopal, Singh and Agrwal (2021) carried out a research entitle "Impact of Online Classes on the Satisfaction and Performance of students during the pandemic of COVID-19". The objective of the study was to identify the factors influencing student satisfaction and performance with online teaching during the COVID-19 pandemic and to establish the relationship between these variables. The study was quantitative and the data was collected from 544 respondents who were studying business administration (BBA or MB). A structural equation model was used to analyze the proposed hypotheses. The results show that four independent factors used in the study: faculty quality, course design, quick feedback and student expectations, themselves have a positive impact on students. Satisfaction and higher student satisfaction have a positive effect on student performance. For education management, these four factors are essential to achieve a high level of satisfaction and performance in online courses. This study is being conducted during the COVID-19 epidemic season to review the impact of online teaching on student performance.

Elfaki, Abdulaheem, and Abdulrahim (2019) conducted a study entitled "Effects of e-learning versus traditional learning on student performance and attitudes". The main aim of the survey was to examine the impact of e-learning on students. A facility-based, quasi-experimental research design was used that was conducted at the Najran University School of Nursing between January and August 2019. Using a targeted sampling technique, 80 nursing students (40 experimental groups + 40 as control group) between the ages of 21 and 24 were recruited to take part in the current survey, the final examination results and a self-filled questionnaire. The results showed that the average scores of the students in the final examination of the e-learning group (experimental) are statistically significantly higher than those of the traditional group (controls). In addition, the results showed that the average of the

overall satisfaction of the students with traditional face-to-face teaching in the control group was lower than the overall satisfaction of the students with e-learning in the experimental group. The difference between the attitudes of the students was significant and in favour of the experimental group.

Singhavi, Chandan and Basargekar (2019) carried out the research entitled “Barriers Perceived by Teachers for Use of Information and Communication Technology (ICT) in the Classrooms in Maharashtra, India”. The study's goal was to determine the most significant barriers to ICT use from the perspective of school instructors, as well as whether these barriers differed depending on the school's delivery language. To determine the relationship between teachers' perceptions of these barriers and their readiness to employ ICTs in the classroom in various school types to determine the preserve value of willingly using ICTs if these restrictions are removed. A quantitative research method was employed for this investigation. Based on a review of the literature, a questionnaire for school teachers was designed and validated by industry specialists, including educators, NGOs working in the field of education, and a statistician. The vote comprised 515 randomly selected teachers from the fifth through tenth grades from various schools in the Greater Mumbai Metropolitan Region. The teachers questioned worked at schools with diverse boards of education and delivery languages, such as English or a regional language (vernacular medium). Several significant findings emerged from the investigation. The ICTs utilization and perceived barriers to use in 75 English medium school teachers' classrooms were compared to regional medium school teachers' classrooms in two types of schools in India. The Chi-Square test reveals that there is a statistically significant difference between the two groups. Teachers, whether they teach in English or in regional medium schools, have an extrinsic or external personality.

There is a shortage of Internet bandwidth, a lack of Internet-connected computers, a lack of educational software, a lack of time, and a lack of accepted pedagogical models among these hurdles. One important obstacle, particularly for regional medium schools, is a lack of regional language e-content. Other hurdles scored low among instructors, including a lack of confidence in using ICTs, a lack of priority placed on ICTs by the school and parents, a negative attitude among teachers, and an unclear knowledge of ICTs benefit. It can be concluded that the majority of the surveyed teachers believe in the importance of ICTs in classroom teaching and are confident in implementing some important barriers such as: inadequate teacher skills, lack of pedagogical models, insufficient time for teachers, and lack of flexibility in implementing ICTs are removed, important barriers such as: insufficient time allotted for using ICTs in the classroom, limitation due to exam-orientation are removed.

Hudson, Rebecca, Porter, Nelson and Mark (2008) published an article entitled "Barriers to using ICTs in mathematics teaching: issues in methodology". The aim of this study was to investigate the barriers to using ICTs in mathematics teaching. The teachers involved are Australian secondary mathematics teachers. The study applied a quantitative method. The researcher designed and piloted a survey questionnaire, which was distributed to secondary schools in the New South Wales Department of Education and Training. The questionnaire has a closed-response format with five open-ended questions. Data were gathered from a variety of public schools situated around Australia. The research comprised twenty-six public secondary schools in New South Wales. These secondary schools were located in the following regions of New South Wales (Australia): Hunter/Central Coast, Illawarra and South Coast, New England, North Coast, North Sydney. Riverina, South Western Sydney, Sydney, Western New South Wales, and Western Sydney are all part of the

Riverina region. The sample consisted of 114 secondary mathematics instructors who agreed to take part in the survey. The survey results indicated that instructors perceived access to computers/computer laboratories as the most significant hurdles to integrating technology into their teaching. United States found striking similarities in the barriers to technology use in the mathematics classroom in their studies of secondary mathematics schools. Similar results might be derived from this survey if the number of instructors naming these as obstacles was simply ranked.

Thematic Literature Review

A thematic literature review is a thorough overview and analysis of a study. According to Cresswell (2007), thematic literature review is a process of analysing and synthesizing themes across multiple studies on a particular topic. It examines and synthesizes the essential concepts and ideas that arise from the problem under consideration. I conducted a thematic literature review to give a comprehensive grasp of the study issue, as well as to discover similarities and differences among studies and gaps in the literature.

Benefits of Virtual Learning

Many researches have shown that there are several benefits of virtual learning. ICTs integration in mathematics education benefits both the teaching and learning processes (Das, 2019). In dynamic learning communities, the technology allowed engagement in a variety of situations and teaching and learning observatory (TLO) enhanced the ability of teachers (Colye, 2004).

Keong, Horani, and Daniel (2006) found that use of ICTs in mathematics instruction can improve the effectiveness of the teaching process as well as students' skills to grasp basic ideas. Similarly, Dhakal (2021) claimed that virtual learning environment improve knowledge, skills, and create opportunities through resource

search and networking.

Colye (2004) has shown teaching and learning observatory (TLO) network to be an effective instrument for bringing together school students, teachers, mentors, teacher educators, and researchers.

The main opportunities VLE brought to F2F classes were to improve study habits, make learning more active, provide opportunities for learning and relearning, and clarify concepts (Dhakal, & Sharma 2016).

Many researches have carried out on the benefits of online learning. Researches have shown that online teaching learning improves students' engagement and achievement. There are only few researches on use of ICTs in face to face classes. There need more researches on this area.

Online Classes and Students' Satisfaction

Many researches showed that online classes has increased student satisfaction. Students are feeling more satisfactory by learning through online classes. Online learning platforms improve academic performance and student satisfaction (Abuhassna & et.al. 2020) that help decision-makers in universities and colleges to plan, evaluate and implement online could use learning platforms in their facilities. Student satisfaction were positively matched on student academic performance (Abuhassna & et.al. 2020). Similarly, overall satisfaction of the students with traditional face-to-face teaching in the control group was lower than the overall satisfaction of the students with e-learning in the experimental group (Elfaki, Abdurraheem, & Abdulrahim 2019). Elfaki, Abdurraheem, and Abdulrahim (2019) showed that the average scores of the students in the final examination of the e-learning group (experimental) were statistically significantly higher than those of the traditional group (controls).

Researches have shown that student satisfaction is high in online teaching. Only few researches are carried out on the use of ICTs in face to face teaching learning. So, I my study was focused on use of ICTs in face to face teaching learning.

Barriers of Online Mathematics Teaching

Many researches showed that there are alots of barriers of online mathematics teaching. According to Bingimalas (2009), the most important limitations of online mathematics teaching are loss of confidence, loss of competence, and absence of get admission to assets. There is a shortage of Internet bandwidth, a lack of Internet-connected computers, a lack of educational software, a lack of time, and a lack of accepted pedagogical models are hurdles of online mathematics teaching (Singhavi, Chandan & Basargekar, 2019). Hudson, Rebecca, Porter, Nelson and Mark (2008) indicated that instructors perceived access to computers/computer laboratories as the most significant hurdles to integrating technology into their teaching. Hudson, Rebecca, Porter, Nelson and Mark (2008) added that United States found striking similarities in the barriers to technology use in the mathematics classroom in their studies of secondary mathematics schools.

While I studied litratures I found researchers have presented different types of barriers while teaching online. That may be because of different context. Researchers are seem to be focused on the barriers of online line learning than the use of ICTs in face to face teaching learning.

E-learning Vs. Traditional Learning

Many researches have compared the e-learning and traditional learning. Elfaki, Abdulraheem, and Abdulrahim (2019) found that the average scores of the students in the final examination of the e-learning group (experimental) are statistically significantly higher than those of the traditional group (controls). In

addition, Elfaki, Abdulraheem, and Abdulrahim (2019) the results showed that the average of the overall satisfaction of the students with traditional face-to-face teaching in the control group was lower than the overall satisfaction of the students with e-learning in the experimental group. The difference between the attitudes of the students was significant and in favour of the experimental group (Elfaki, Abdulraheem, & Abdulrahim, 2019).

Many researches have carried out on the benefits of online learning. Researches have shown that online teaching learning improves students' engagement and achievement. There are only few researches on use of ICTs in face to face classes. There need more researches on this area.

From empirical and themetical literature review I found researches were focused on online teaching learning rather than use of ICTs in face to face teaching learning. Researches have found the opportunities, barriers, and students' satisfaction etc. of online teaching learning. I found there is variation between the results of the same research question. This may be because of situational difference between the researches.

Theoretical Review

The intention of theoretical review is to analyse the corpus of theory that has developed in relation to a topic, concept, theory, or phenomenon in a specific manner. The framework, concepts, models, or particular theories that support our investigation are explicitly described in the theoretical review. The theoretical literature review assists in determining what theories currently exist, their linkages, the extent to which existing ideas have been examined, and the development of new hypotheses to be tested. The analytical issues might be a single theoretical notion or an entire theory or framework.

I reviewed several established theories and models. Constructivist theory, Connectivism theory, theory of reasoned action (TRA), technology acceptance model (TAM), theory of planned behaviour (TPB), unified theory of acceptance and use of technology (UTAUT), and theory of technological pedagogical content knowledge (TPACK) were some of them. I decided to use multiple theories and a model for my study so I shaped my research according as constructivist and Connectivism theories, and TPACK model. I connected my research to these theories and model in tools construction and connecting the finding.

Constructivism Theory

According to Akpan, Igwe, Mpamah and Okoro (2020), social constructivism is a collaborative form of studying based on interaction, discussion and expertise sharing amongst learners themselves. Akpan, Igwe, Mpamah and Okoro (2020) explain constructivist theory deemphasizes teacher-monotony in the classroom and encourages energetic interplay among learners, the instructor and other components of the educating learning process. The focal points of the constructivist theory are learner's questions and interests. Students build on what they already know. Constructivist theory emphasizes on interactive learning and student-centered teaching. Teachers' role is to help students to assemble their very own knowledge. Students' effort is the primary in constructivist theory. Vygotsky (1978) introduced Zone of proximal development (ZPD). ZPD is the gap between what a learner has already mastered (actual degree of development) and what he or she can gain when furnished with educational assist (potential development). In my study I developed open ended questions or guidelines for students and teachers to know how students were being active through ICTs. How were they collaborating ICTs in leaning or creating new knowledge upon the previously acquired knowledge? How students

were interacting among themselves? How were students getting ZPD through ICTS? I collected data based on this theory. I integrated this theory while interpreting data and formulating them. I used this theory in conclusion.

Theory of Connectivism

Downes (2007) stated that knowledge has many authors and facets, it looks different to each person, and changes moment to moment. A piece of knowledge isn't a description of something; it is a way of relating to something (Downes, 2007).

Theory of connectivity relates the theories as demand of research. It denies the compulsion use of unique theory in a research. Connectivism is a relatively recent learning theory that proposes that researchers integrate thoughts, theories, and general knowledge in a productive way. It recognizes that technology is an important element of the learning process and that our continual connectivity allows us to make choices about our learning. It also encourages group cooperation and debate, allowing for diverse points of view and views when making decisions, solving problems, and making sense of information.

The fast change brought about by technology significantly limits the ability of classical learning theories to describe learning. Connectivism is described as practical knowledge, in which knowing where to get knowledge is more essential than knowing how or when to find it. What such knowledge composes. According to Duke, Harper and Johnston (2013) George Siemens and Stephen Downes created Connectivism, a philosophy for the digital era that rejects the limitations of behaviourism, cognitivism, and constructivism. While the theory given is significant and relevant, is it a tool to be utilized in the learning process for teaching or curriculum rather than a stand-alone learning theory? It has compelled educators to reconsider what is being done in digital education to analyze, discuss, and philosophize about how each component fits

together. The thesis that knowledge is distributed across a network of connections, and therefore that learning consists of the ability to construct and traverse those networks (Downes, 2007).

In this study I used multiple theories, thoughts, knowledge and experiences. I considered technology specialy ICTs as essential part of mathematics teaching and learning. I wanted to know how teachers and students are using ICTs in teaching and learning mathematics. How were they facing the problems? How the problem can be solved? These all were connection of technology with teaching learning. So I used this theory in my research.

Technological Pedagogical Content Knowledge (TPACK) Model

The intersection of technological knowledge (TK), pedagogical knowledge (PK), and content knowledge (CK) is defined as technological pedagogical content knowledge (TPACK). According to Malubay and Dagupo (2018) strong and significant knowledge of technology, pedagogy, and content, as well as their interdependence, defines teachers' creativity and effectiveness in developing and delivering new modes of representation and solutions to mathematical content and problems, making them responsive to 21st century learners. This finding proves the theory of TPACK. My study is oriented to practice of integration of ICTs in mathematics classroom. It includes all three aspects of TPACK. My thesis includes ICTs for technology, teaching and learning for pedagogy and mathematical content. So this theory is applicable in my research. I lined this theory in objectives, research questions, open-ended subjective questions or guidelines, data collection, data analysis, them formation, and in conclusion for teachers. I shaped my research according to this theory for teachers.

Mishra and Koehler (2006) created the Technological Pedagogical Content

Knowledge (TPACK). Teacher relies on three domains of knowledge for efficient integration of ICTs into teaching and learning (IITL). The areas include content knowledge (CK), pedagogical knowledge (PK), and technological knowledge (TK).

Content knowledge (CK). Mishra and Kohler (2006) defined CK as knowledge about the actual topic matter to be learnt or taught. Mishra and Koehler (2006) found that a teacher must know and understand the subject that he or she teaches, including understanding of central facts, concepts, theories, and methods, if the instructor is to integrate the subject. In my study content knowledge indicates the knowledge of mathematical content.

Technological knowledge (TK). Mishra and Kohler (2006) described TK as knowledge of traditional technologies such as books and chalkboards, as well as more modern technology such as the Internet and digital video, and how to use them. They claimed that a teacher who has good understanding of operating systems and computer hardware, as well as the ability to use standard sets of software tools (e.g., word processors, spreadsheets, browsers, e-mail, Zoom, Team, Google class) and how to install and remove peripheral devices, install and remove programs, and create and archive documents, among other things are aware of technical knowledge. In my research technical research means knowledge of ICTs.

Pedagogical knowledge (PK). Mishra and Koehler (2006) defined PK as a thorough understanding of the processes or techniques of teaching and learning. PK includes values and aims, classroom management, lesson planning, student evaluation etc. Mishra and Koehler (2006) contended that a teacher with a strong understanding of PK is more likely to use technology into his or her instruction, taking into account how children learn best in a specific classroom setting and the character of learners.

Mishra and Kohler (2006) discovered that the interaction of these three

knowledge domains, CK, PK, and TK, results in three paired knowledge domains, namely pedagogical content knowledge (PCK), technological content knowledge (TCK), and technological pedagogical knowledge (TPK).

Pedagogical content knowledge (PCK). PCK is intersection of PK and CK. We can define PCK as the methodological knowledge which is useful in teaching the specific content of mathematics. Mishra and Kohler (2006) defined PCK as pedagogical knowledge applicable to the teaching of specific material, such as knowing what teaching techniques match the topic and how the components of the content may be organized for better teaching.

Technological Content Knowledge (TCK). TCK is intersection of TK and CK. It is the knowledge of apply the technical knowledge while teaching content of mathematics. According to Mishra and Koehler (2006) TCK is knowledge about how technology and content are connected to one another. They went on to say that a teacher must understand not just the subject topic he or she teaches, but also how technology may transform the subject matter.

Technological Pedagogical Knowledge (TPK). Mishra and Kohler (2006) stated that TPK is knowledge of the presence, components, and capabilities of various technologies as they are utilized in teaching and learning contexts, and understanding of how teaching may change as a result of employing specific technology.

Technological pedagogical content knowledge (TPACK). TPACK as the junction of all three bodies of knowledge CK, PK & TK. Mishra and Kohler (2006) claimed that development of TPACK is critical for effective technology instruction since knowing TPACK is more than just understanding technology, material, or pedagogy in isolation, but rather how various kinds of knowledge interact with one another.

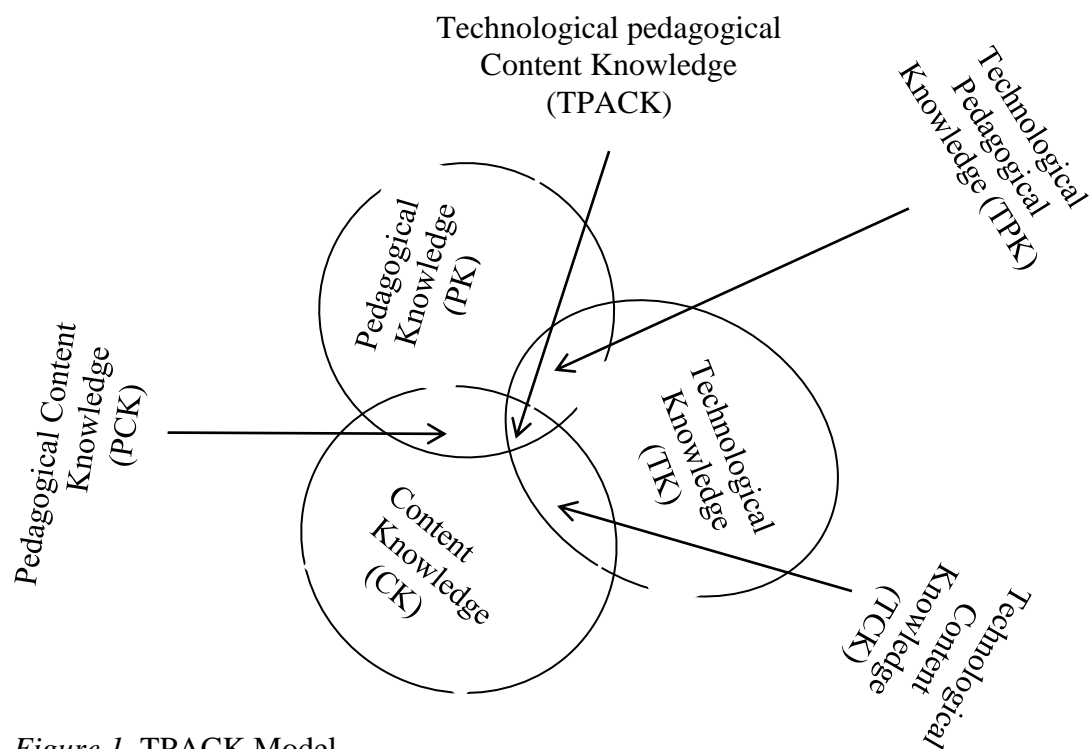


Figure 1. TPACK Model

Conceptual Framework

Conceptual framework is developed through literature studies aided in achieving research objectives, answering research questions, and carrying out the research activity as a whole smoothly (Acharya, 2015). It is a crystal clear snap short of the road map of research process.

Conceptual framework of my research is as expressed in diagrammatic form in figure 2.

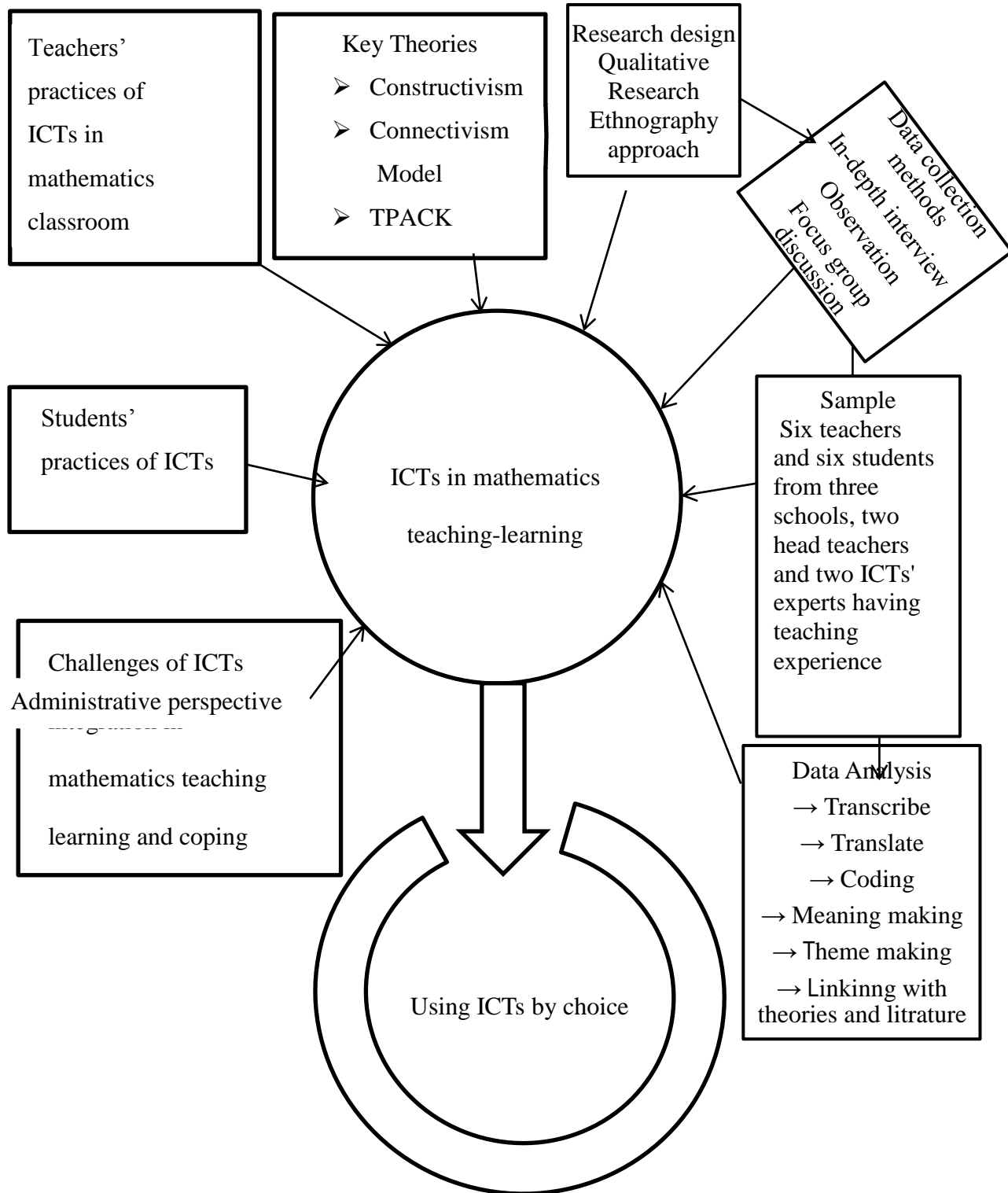


Figure 2. Conceptual cum Theoretical Framework

Figure 2 presents the roadmap of my research actions. The key focuses of my research were practice of ICTs, obstacles, and way forward in classroom. For this I used in-depth interview, participant observation and focus group discussion of students as methods of data collection. My research design was qualitative with ethnographic approach. The population of my research was mathematics teachers and students of class 9 and 10 of Kathmandu district. Three schools where teachers are teaching mathematics through ICTs were my research site. Six teachers and six students of three schools, two head teacher, and two ICT expert with experience of teaching were sample of my research. I followed constructivism, and Connectivism theories and TPACK model for my research. ICT friendly classroom was my possible outcome.

Implication of the Review for the Research

Literature review provides me the context of my research. It also gives me wider knowledge on ICTS and mathematics classroom. I used the theoretical literature review while constructing tools and analyzing data. It helped me to determine the research procedure but the main implication of literature review for my research was gap spotting.

Gap Spotting

Gap-spotting refers to the identification of different gaps in current literature (for example, misunderstanding, neglect, and application spotting), but it does not aggressively question the assumptions underpinning existing theory (Sandberg & Alvesson, 2011). Research gap helps researcher to formulate research questions which provide a way of research and also signify research. I studied various articles, thesis, and other documents available online and which are related to my topic. I found most of the ICT related researches are on online teaching learning. Only few researches are

carried out on use of ICTs in face to face learning. My research was focused on the use of ICTs on both face to face and online learning. Researches have found opportunities and barriers related to use of ICTs for online classroom quantitatively from the positivist perspective but they have not researched about how teachers and students are practicing ICTS in face to face mathematics qualitatively specially ethnography approach. Researchers didn't focus on how students and teachers are facing problems in face to face mathematics classroom? So, there was a research gap in this area to fulfill this gap I was interested to carry out this research entitled practices of ICTs in mathematics classroom: opportunities and challenges.

Chapter III

METHODOLOGY

Research methodology is the particular methods or strategies used to identify, select, process, and analyse facts about a topic. In a lookup paper, the methodology section approves the reader to seriously evaluate standard validity and reliability. The methodology area answers two predominant questions: How will the records be collected or generated? How will it be examined? Methodology is a theory of methods with respective tools and techniques; it is a graph of ways of thinking and doing (Callaos & Callaos, 2002). It helps to yield the way of study. It is a guideline for ways of knowing, being and valuing reality which depends upon nature of research. In this chapter I discussed on research paradigm, research design, study site, sample of the study, profile of research participates, data collection tools and techniques, data analysis procedure, quality assurance, and ethical consideration.

Research Paradigm

A paradigm is “a basic set of beliefs that guide action” (Guba, 1990, p.17). According to (Creswell, 2007) if researchers choose a qualitative approach then they shape their research by taking to the research paradigm. Research paradigm is a mental model that shapes and impacts how researchers see their subject of study. Research paradigms are ‘the entire constellation of beliefs, values, techniques, and so on shared by members of a given community’ (Kuhn, 1970, p.175). Creswell (2007) stated that there are four types of research paradigms. Post positivism, social Constructivism, advocacy/participatory and pragmatism are types of research paradigm (Creswell, 2007). Positivism, constructivism or interpretive and pragmatism are three most common types of paradigm.

My research oaradigm was Constructivism or interpretive. Honebein (1996)

defined constructivism or interpretive as a philosophical paradigm in which humans construct their own understanding and knowledge of the universe by experiencing things and reflecting on those experiences.

Ontology

The study of existence is known as ontology (Thomas, 2021). Ontology is concerned with what truly exists in the world that people may learn about. Ontology assists researchers in determining how confident they can be about the nature and existence of things under investigation (Thomas, 2021).

Ontology of my research was subjective. In this research I assumed that truth is constructed by person or society. My research was based on multiple truths created by my participants.

In my study, I considered that teaching and learning through ICTS can improve students' achievement and understanding of learning. Use of ICTS in mathematics classroom may be a better option for teaching and learning. Some teachers and students were using ICTS in mathematics classroom. They had their own experience and perception on ICT integrated mathematics classroom. I assumed that there were many barriers in teaching and learning mathematics through ICTS. The obstacles faced by teachers and students are different and similar as well. I thought there were a variety of experiences and understanding toward integration of ICTS in mathematics classroom. So multiple truths were ontology of my research. In fact the ontology of my research was subjective based on multiple realities.

Being a teacher I thought about ICTs integration in mathematics classroom. I desired to know how teachers are practicing ICTs in mathematics classroom? How students use ICT tools while learning mathematics? How teachers and students face obstacles while using ICTs in mathematics classroom? How are they solving the

problems? My research explored the perception and experience of teachers and students for IIMC. So that constructivism or interpretive research paradigm is suitable for my research. In my research research paradigm was a set of widely apprehended ideas and assumptions regarding ontological, epistemological, and methodological issues within a research community.

Epistemology

The study of knowing is known as epistemology (Thomas, 2021).

Epistemology is concerned with the validity, scope, and techniques of gaining knowledge and with what defines a knowledge claim, how knowledge may be gained or generated, and how the extent of its transferability can be judged (Thomas, 2021).

Epistemology of my research was the teachers', students', head teachers', and experts' perceptions and experiences. I maintained report relations with my participants to get the knowledge or reality. I used dialogical and dialectical method to knowledge. The environment of the classroom which I observed was also epistemology of my research.

I got information and data from teachers and students. Teachers and students' perceptions and experiences were valuable for my research. In this study, my epistemological position was to embrace numerous realities derived from the varied viewpoints of the participants. I had no absolute reality concerning virtual learning in mathematics. I collected the information being close to my participants through dialogical and dialectical manner.

Axiology

Axiology is the theory of value. Axiology focuses of what a researcher value in his/her research (Thomas, 2021).

My research was value laden. The value of my participants has effected my

research. Thought, experiences, and mindsetup of my participants played important role during data collection. So, axiology of my research was value laden.

My study helped to understand the perception experience of teachers and students in IIMC. This research clarified the obstacles and way forward for the obstacles for IIMC. This research helped policy makers and government to design the curriculum according to ICTs and develop apps for teachers and students which are easy to run. This study helped the school administration to develop better ICT friendly environment in school. This research helped teachers and students to raise their problems. My research gave better solution for those problems through this thesis. So my research was value laden.

On other hand digital teaching and learning in mathematics was value laden in my investigation because it influenced by perception, cooperation, engagement, and interaction. Participants were able to speak freely about their personal experiences.

I gave equal weight to their various emotions and views. I accepted all points of view equally because they were all equally crucial to the completion of the study. Because I had lack of objective value, I didn't demonstrate the worth of feelings/experiences throughout the interview and focus group discussion.

Research Design

The research design is overall approach that researcher adopts to combine the many components of the study in unified and rational way solving the research questions (Thomas, 2021). Research design serves the blueprint for obtaining, transcribing and coding data; making theme; and linking with theories and literature (Thomas, 2021).

I adopted qualitative research design with ethnography approach. In my research qualitative research design with ethnography approach was concerned with

exploring meaning and the way of individuals understanding.

Qualitative Research with Ethnography Approach

The theoretical foundation of qualitative research is subjective reality as truth, a true knowledge (Sharma et al., 2011). Qualitative research is considered "naturalistic inquiry" in the sense that it is performed in a natural context while attempting to avoid any intentional manipulation and distortion of the informants' surroundings by the researcher (Tames, Stigler & Perry, 1998; as cited in Creswell, 2007). Narrative research, Phenomenology, Grounded, case study and ethnography are five major approaches of qualitative research (Creswell, 2007). Ethnographic research is a qualitative approach in which researchers watch and engage with study participants in their natural context.

I studied how teachers and students are practicing the ICTS culture in mathematics classroom. What are the problems of ICTs integration in mathematics classroom? How were teachers and students facing problems? To study those problems, I used emerging qualitative approach ethnography. I conducted interviews and collected data in a natural setting that was sensitive to the people and places being investigated. I applied inductive data analysis to find themes. The final written report or presentation included the voices of participants, the reflexivity of the researcher, and a complex description and interpretation of the problem and it extends the literature or signals a call for action (Creswell, 2007).

Qualitative researches study things in their natural setting attempting to make sense of or interpret phenomenon in terms as of the meaning people bring to them. Qualitative research involves the studies and collection of a variety of empirical materials- case study, personal experience, life history, interview, observational, historical, interaction and visual texts that describe routine and problematic moments

and meaning in individual's lives (Denzing & Lincoln, 2005). Since, human behavior was always bound to the context in which it occurs, the social reality, e.g. human cultures, cultural artifacts and institutions, through which human experiences derive its meaning from social, historical, political influences. Such human behaviours are difficult to reduce to variables in the same situations as physical reality. It needs qualitative inquiry that seeks to understand human and social behaviour. One of the important things in qualitative research is that the researcher has to perform a role of human tool of data collection that needs relevant and appropriate knowledge and skills about it. Qualitative research emphasized on inductive analysis of data that proceeds to find theory to explain the data.

I used qualitative research design with ethnographic approach because studies need qualitative inquiry to understand human and social behaviour (Denzing & Lincoln, 2005). My research objectives were connected to social behaviour. To fulfill the objective of practice of ICTs in mathematics classroom I have to observe the classes of teachers in natural setting. I used ethnographic approach so that I could observe and collect data in the natural setting. I build rapport then observe their classes. I interviewed them multiple times informally. I spent six months with my participants then I observed their classes and took interviews and gathered real data in natural setting then analysed those data.

Study Site

Matching the criteria for research site selection is one of the needed and distinctive elements of a trial, which increases the possibility that the trial will be executed properly and that enough high-quality data will be accessible to meet the study's aims (Warden, Trivedi, & Greer, 2012). The site assortment is a vital task for the study. Suitable site selection can provide easy access, rapport relationship with

informants that helps to accelerate the collection of data for our objectives. I selected three schools as my research site. I used K₁, K₂, and K₃ as pseudo name. I selected those schools they had facility of ICTs. Teachers and students are using ICTs in mathematics classroom.

Sample and Sampling

My research was the qualitative with ethnographic approach, so the sample size in this study was not fixed. There are not rules for sample size in qualitative inquiry (Anderson et al., 2014). The number of individuals or observations included in a research was sample size. My research design is qualitative so there is no fixed number of sample sizes to be selected for my study. The sample size of research depends upon the researcher what he/she wants to know, what the purpose of inquiry is what can be credibility of the study and what can be done with available time and resources.

Since my research design was qualitative, I choose purposive sampling. It was a non-probability sampling based on characteristics of the population and objective of the study. Purposive sampling was convenient for me to choose sample according to my desire.

I purposively selected six mathematics teachers (two from each research sites) and two head teachers. Two experts with at least two years teaching experience were also selected purposively as my sample. I purposively selected six students (two from each research sites) grade 9th and 10th.

I selected the teachers who were using ICTs in teaching learnig can express their thoughts infomt of me without any fear. I laso had good personal relation with those teachers. Their experiences seemed to be sufficient for my study that's why I chossed those teachers. Similarly I selected those students who were very intrested in

teaching learning through ICTs and with whom my relation was good. Their experiences seemed to be sufficient for my study that's why I crossed those teachers. I selected those head teachers and experts who were interested in ICT integration in classroom. I selected them because my relation with them was very good and they gave me sufficient time for interview. Data from them were sufficient for my research.

Profile of Research Participants

After selecting Sample I mentioned the profile of participants with pseudo name and address. I have maintained their confidentiality carefully while writing profile.

T₁ was a trained permanent mathematics teacher of secondary level with qualification M.Ed. in mathematics education. He had experience of 25 years of teaching mathematics in public secondary school. He was dedicated professional candidate. He was regular punctual and responsible personality. T₂ was a trained permanent mathematics teacher of secondary level with qualification M.Ed. in mathematics education. He had experience of 10 years of teaching mathematics in public secondary school. He was dedicated professional candidate. He was regular punctual and responsible personality.

T₃ was a trained mathematics teacher of secondary level with qualification M.Sc. in mathematics. He had experience of 7 years of teaching mathematics in public secondary school. He was dedicated professional candidate. He was regular punctual and responsible personality. T₄ was a mathematics teacher of secondary level with qualification B.Sc. in mathematics. He had experience of 2 years of teaching mathematics in public secondary school. He was dedicated professional candidate. He was regular punctual and responsible personality. T₅ was a mathematics teacher of secondary level with qualification B.Sc. in mathematics. He had experience of 5 years

of teaching mathematics in public secondary school. He is dedicated professional candidate. He is regular punctual and responsible personality. T₆ was a mathematics teacher of secondary level with qualification B.Sc. in mathematics. She had experience of 5 years of teaching mathematics in public secondary school. She was dedicated professional candidate. She was regular punctual and responsible personality.

H₁ was head teacher of secondary school. He had 4 years of experience of administration. H₂ was head teacher of secondary school. He had 3 years of experience of administration.

E₁ was an ICT expert having experience of two years of teaching. His qualification was M.CA. He had been involved in more than fifteen teacher's trainings as trainer. E₂ was an ICT expert having experience of two years of teaching. His qualification was B.CA. He had been involved in more than ten teacher's trainings as trainer. S₂, S₄, and S₆ were students of class 9 whereas S₁, S₃, and S₅ were students of class 10. S₁ and S₂ are the students of school K₁. S₃ and S₄ are the students of school K₂. S₁ and S₂ are the students of school K₁. S₅ and S₆ are the students of school K₃. S₅ is my female student participant and remaining are my male students participants.

Data Collection Methods and Tools

Methods that are used to collect the data are data collection methods. Creswell (2007), visualized data collection as a series of interrelated activities aimed at gathering good information to answer emerging research questions. Trustable data can lead a research to trustable finding. Appropriate data collection methods can help a researcher to collect trustable and in depth data. An important step in the process is to find people or place to study and to gain access and establish rapport with participants, so that they provide good and real data. Data collection is an important

part of the study. On the basis of the data, we can study and analyze every aspect of the study. Commonly there are four types of data collection methods for research. They are observation, questionnaire, interview, and focus group discussion. To find answer of my research questions I used in-depth interview with my teacher, head-teacher, students, and expert participants, classroom observation of my teacher participants; focus group discussion with student participants as data collection methods.

Research tools are the basic instruments to gather data, to seek possible solutions for observed problems. Interview guideline for teacher participants, interview guideline for student participants, interview guideline for headteacher participants, interview guideline for expert participants, guideline for focus discussion with student participants and classroom observation guidelines were the research tools through which I collected data.

In-depth Interview

Interview is a two-way interaction between researcher and participants as in the form of interviewer and interviewee in which interviewer creates situations that can attract the attention of respondents for enough period of time in asking questions and answering the questions which interviewee puts his/her understanding and meaning (Creswell, 2007). Kerlinger (1986; as cited in Adhikari, 2006) described interview as face to face interpersonal role situation in which one person, the interviewer, asks a person being interview, the respondent and questions designed to obtain answers pertinent to the purpose of the research problem. In-depth interview also known as unstructured interview could be regarded as informal interview. It issued to discover the in-depth understanding of people in the context under the study (Bailey, 1982; as cited in Adhikari, 2006). It can be done in a day to day

conversational way in which interviewer does not know whether he/she had been interviewing or not. This interview will help to create a friendly situation that opens up a free feeling environment for both researcher and respondent.

In my study all required information was not possible to gather through the observation, focus group discussion and documents. So, I carried out open ended interview to answer my research questions. Before conducting interviews with teachers, students, head teachers, and experts. I created an interview guideline based on research questions and then asked to chosen students, teachers, head teachers, and experts. Before interviewing, I informed them about the topic of the research for which they interviewed. Some questions were raised according to the situation available. I interviewed all of my student, teacher, head teacher, and expert participants using unstructured questionnaires. I formally interviewed each of them for two times but informally I met them for several times.

Participant Observation

Observing in a setting is a special skill that requires addressing issues such as the potential deception of the people being interviewed, impression management, and the potential marginality of the researcher in a strange setting (Hammersley and Atkinson, 1995; as cited in Creswell, 2007). Observation is a kind of tools that helps to seek knowledge through the use with sense i.e. eyes, nose, tongue, and skin. It has great importance not only in research work but also in our daily lives (Adhikari, 2007)wrote that direct observation has the advantages of putting researchers into first hand contact with reality.

In my study, classroom observation was a data collection method. Classroom observation was used to capture the physical setting and environment of schools and classrooms. I observed two classes of each of my teacher participants for six months. I

observed ICTs' labs and classrooms where teachers were mathematics using ICTs.

Observation guideline was developed with reference to research objectives.

Teachers, students, and head teachers were pre-informed about the purpose of observation for permission. After that I entered classroom. I was inert during observation. I made notes of classroom environment for my research problem. After observation I prepared field note based on places, events, activities. Then I arranged description of observation in field-note.

Focus Group Discussion (FGD)

A focus group discussion brings individuals together with comparable backgrounds or experiences to explore a specific topic of interest (Creswell, 2007). It is a type of qualitative study in which participants are asked questions about their views, attitudes, beliefs, opinions, or ideas (Creswell, 2007). Participants in focus group discussions are allowed to communicate with other group members, which, unlike other research methodologies, are encouraged conversations with other participants (Health Research and Social Development Forum [HERD], 2016).

I made a focus group of my student participants to discuss on the various topics related to my research. I conducted the focus group discussion of students only so that they can clearly express their voices and thoughts. Total members of my focus group discussion (FGD) were six. All the students participants to whom I interviewed were members of my FGD.

I conducted two FGD of same group of my student participants. It was Saturday, to conduct first focus group discussion I called all of my participant students in school K₁. Then I took them to the hall of the school where I already set the chairs and table so that they sit and discussed face to face. I clarified the objective of focus group discussion and conformed them that this would be confidential. Then I

opened the voice recorder application of my mobile and put some questions in the group. I recorded all the voices of them in my mobile. At the end of focus group discussion I thanked them and offered some fruits. I conducted second focus group discussion on the Sunday after two Saturdays. I called all of my participant students in school K₁. Then I took them to a class of the school where I already set the bench and desk so that they sit and discussed face to face. I again clarified the objective of focus group discussion and conformed them that this would be confidential. Then I opened the voice recorder application of my mobile and put some questions in the group. I recorded all the voices of them in my mobile. At the end of focus group discussion I thanked them and offered some snacks.

FGD of students helped me to identify the students' ways using ICTs in mathematics classroom. I also discussed about the barriers of ICTs integration in mathematics classroom and their possible ways forwards. It also helped me carry out differences in the ways of ICTs in mathematics classroom of different schools. It facilitated me to find out the problems of students and teachers and their differences. FGD of students helped me to check or evaluate their cross perception and obstacles.

Data Collection Procedure

Data collection refers to gather information from vivid sources through the application of multiple data gathering methods to attain the objectives of the research under consideration (Niure, 2014). For my study, the data and information were collected using tools in-depth interview with students, teachers, head teachers, and expert participant, classroom observation of teacher participants, and focus group discussion (FGD) of students.

To collect the primary data by using my data collection tools. I observed, listened, interacted, and recorded the essential data for my research. I collected data in

three steps. I collected data for six months. I observed one class of each participant. First were in-depth interviews with my participants. I used semi-structured interview schedule and questionnaire for in-depth interviews. Questionnaires for interviews consisted direct questions to my participant about their experiences, opinions, feelings and knowledge. I recorded each in-depth interview in my mobile. Second was classroom observation. For classroom observation I observed the classroom environment, teachers' behaviour, students' engagements, availability and management of ICT tools. I made notes during classroom observation. Third was focus group discussion of students. I prepared some semi-structured schedule and questionnaire for FGD. I called each of my student participants in a school and conducted FGD. I recorded their voice in my mobile.

Data Analysis Procedures

Data analysis in qualitative research consists of preparing and organizing the data for analysis, then reducing the data into themes through a process of coding and condensing the codes and finally representing the data in figures, tables or a discussion (Creswell, 2007). In my study, I collected data through in-depth interviews with teacher, student, head teacher and expert participants, classroom observations of teachers, and focus group discussion of students.

I analyzed the data by using Thomas (2006) general inductive method. According to Thomas (2006), the goals of an inductive approach are to (a) condense raw textual data into a brief, summary format; (b) establish clear links between the evaluation or research objectives and the summary findings derived from the raw data; and (c) develop a framework of the underlying structure of experiences or processes that are evident in the raw data. Transcribe, coding, theme making, and linking with theories are the steps of data analysis (Thomas, 2006).

Transcribe

My participants were comfortable with in Nepali language rather than in English. So, I prepared to take interview in Nepali language. I used Nepali language for in-depth interviews with teacher, student, head teacher and expert participants and focus group discussion with student participants. I used Nepali language because they can express their views clearly. Then I transcribed their voices in Nepali as it was and made note.

Translate

For my purpose of my research, I translated the data from in-depth interview and FGD into English without changing the sense and made notes. I also used google translator to translate the transcribed data.

Coding

I coded the transcribed data. I wrote and read transcripts many times then generated codes. The common data was given same code. I used the theory of trial and error for coding the data. I used open coding (Creswell, 2007) to code my data obtained from classroom observations of teachers; interviews with teacher, student, headteacher, and expert participants; and focus group discussion with student participants.

Theme Generating

I created themes by studying codes many times. I categorized the data by the help of common codes and generated the themes.

I refined the theme as per my research questions. For the purpose of analysis, the themes were analyzed for answering the research questions. The important paraphrases with same meaning were brought together and summarized to support the argument whereas less relevant passages with same meaning were skipped.

I adopted cross match and triangulation to maintain the validity and reliability of the results of my study. I triangulated the data obtained from in-depth interview, participant- observation, and focus group discussion. After making theme I drew meaning from theme and connect with suitable theories and models. I also checked either the result is matching with the data collected or not.

Linking With Theories and Litratures

I linked my findings and themes with Constructivism, Connectivism and other theories and litratures.

Quality Assurance

Quality assurance (QA) in qualitative research refers to procedures and policies that ensure data integrity, quality, and dependability are maintained at all phases of the research (Lincoln & Guba, 1985). QA is necessary for a variety of reasons. The most evident is that the entire purpose of research initiatives is to provide trustworthy data that leads in rigorous and reproducible research outcomes. Credibility, transferability, dependability, and confirmability are four types of trustworthiness in qualitative research (Lincoln & Guba, 1985).

It is crucial to maintain a high degree of quality in research. To maintain the quality level, cross matching, triangulation, and member verification was performed. I followed Lincoln and Guba (1985) and maintain four types of QA.

Credibility

The credibility criteria entail determining that the findings of qualitative research are credible or believable from the perspective of the research participant. The degree to which a study report is credible and suitable, with special reference to the amount of agreement between participants and the researcher, is referred to as credibility (Mills et al., 2010).

To preserve the credibility of my study, I spent much time in observing and engaging with diverse participants about their job. After gathering information, I took notes, asked similar sorts of questions to other participants, and attempts to derive real-world practices from that knowledge.

Transferability

The degree to which the findings of qualitative research may be generalized or transferred to different contexts or settings is referred to as transferability (Lincoln & Guba, 1985).

To preserve transferability, I placed the context first. I conveyed the majority of the situation by using detailed descriptions of observations, interviews, and focus groups.

Dependability

Dependability relates to the consistency and reliability of research findings, as well as the extent to which research techniques are recorded, allowing someone outside of the study to monitor, audit, and monitor the research process (Sandelowski 1986). I mentioned the others' findings at similar context and compare with my findings. I recorded all the steps in my research. In-depth interviews and focus group discussion were recorded in my mobile. I also captured some pictures of classroom observations. My supervisors monitored my research. I audited my research according to their guidance.

To ensure the dependability of my research, I rationally selected locations, samples, and time to observe, in-depth interviews, and focus group discussion and included in the study. To ensure dependability, I endeavoured to retain credibility and transferability.

Confirmability

The objectivity of study throughout data collecting and analysis is referred to as confirmability. There must be agreement between two or more independent individuals on the accuracy, relevance, or interpretation of the data (Polit and Beck, 2012).

I went over the research technique in detail. As a qualitative researcher, I considered my history and position to determine how they affect the research process (i.e., selecting the topic, choosing the methodology, analyzing the data, interpreting the results, and presenting the conclusions). The analysis and interpretation were based on the participants' genuine perspectives. As a member of the same population group, I had my own experiences and opinions, but they were not dissimilar to those of the participants.

On other hand to attain confirmability, I showed that the findings are clearly related to the conclusions in a way that could be followed and duplicated as a process. To maintain confirmability I connected the findings to the conclusion.

Ethical Considerations

The standards that must be maintained when conducting any sort of study are known as ethical consideration. Ethical concerns ensure that no human rights are infringed and that the study has no secret intent. Lipson (1994), classified ethical concerns as follows: informed consent processes; deceptions or covert actions; secrecy toward participants, sponsors, and co-workers; advantages of research above dangers; and participant demands that go beyond social standards (Lipson, 1994, Cited in Creswell, 2007).

My research agendas were mentioned as objectives of my research. My research is free from any type of covert objective. I respected the human right

consideration during data collection and analysis. To get permission of the participants before in-depth interview, classroom observations, and focus group discussion, I informed about my research. I made every effort to reduce the possibility of grievance. I avoided dishonest techniques and provided participants the option to withdraw from my study at any time. I didn't force any one of them to respond or engage in the focus group discussion. I maintained the secrecy of the participant who were sample of my research. I used pseudo name of my participants. I was careful while paraphrasing parts of book or article or documents so that the theme remains same. I sighted all those writers from whom I have taken the information and mention them in references.

Chapter IV

ICTS' PRACTICES IN MATHEMATICS CLASSROOM

The first objective of my research was to explore the practice of ICTs in mathematics classroom. In this chapter I have explored various ways of practice ICTs in mathematics classroom. This chapter includes detail descriptions and analysis of the ways in which teachers and students are using ICTs in mathematics classroom in various themes. Students' engagements, demonstrating the resources, gamification of learning mathematics, mathematics learning by apps, and teaching mathematics by digital technologies are themes through which I have explored the ways of ICTs practice in mathematics classrooms.

Through the process of in-depth interview with my teacher participants, students, experts and head teachers, classroom observations of my teacher participants, focus group discussion with students and informal interactions with teachers, students, experts and head teachers, I have captured the ways in which teachers are teaching mathematics using ICTs and the way in which students are learning mathematics through ICTs. I found the ways in which ICTs are used to mathematics teaching and learning are differ from person to person, some are using it as teacher centered way where as some are using as student centered method. But the essential of the various ways of practicing ICTs in mathematics classroom is to promote the ICTs integration in mathematics classroom. In the context of Nepal it is very beginning stage of utilization of ICTs in mathematics teaching-learning but teachers and students are using it in constructive way. The integration of ICTs in everyday school practice needs time and systematic efforts. Helping teachers to develop positive attitudes towards ICTs in education is a complex task, determined by many factors (personal, pedagogical, technical barriers, school

culture factors) which affect teachers' beliefs, educational priorities and decisions in school practice (Jimoyiannis, 2008).

Students' Engagement

Students' engagement refers to students' participation in educationally effective practices in both inside and outside of the classroom. It includes both cognitive and non-cognitive activities of students. According to Kuyini (2007), student engagement refers to the degree of attention, curiosity, interest, optimism, and passion that students show when they are learning or being taught. It is one of the most important factors for effective teaching and learning. Student engagement is crucial since it addresses a student's level of attention, effort, positive emotions, and commitment in the learning process (Handelsman et al., 2005).

In this issue one of my teacher participants T₂ conveyed his view as

Students become very engaged during learning mathematics through ICTs. They do their work using computer. They became curious during learning mathematics through ICTs. They asked various questions and also find the solutions of the problems by interacting with me and among themselves. They solve the problems by using various ICT tools like Google, YouTube etc. While teaching statistics using ICTs in computer lab I taught them in excel by using traditional methods. To find mean of individual data: students solve problems.. They used the tables of excel to compute multiplication and addition required for mean, median etc (Interview transcription February 6, 2022).

My other teacher participant T₃ expressed his view as

Sometimes I use ICTs for teaching mathematics. Students seem to be very engaged, curious and happy while learning mathematics through

ICTs. While teaching mathematics through ICTs they try to do their self and become very active for learning. Even those students who don't like mathematics become very active in searching different method of solving problems (Interview transcription March 9, 2022).

Similarly my teacher participant T₄ conveyed his opinion as

One day I took students in ICT lab and gave a question “If a shopkeeper bought 6 chocolate for Rs.1 then to get 20% profit how many chocolate should be sold for Rs.1?” in class 9. Students were very busy and motivated to solve the problem. Some of the students were searching in Google, where some were watching related video in YouTube. In fifteen minutes students started to show me the solution by solving on copy. I found that their methods of problemsolving were different. They were using different sources and enjoying the ICT integrated mathematics class (Interview transcription April 12, 2022).

My student participant S₃ articulated his view as

It is very interesting to solve the problems by using ICT tools. It provides better opportunities to learn mathematics. We fell very excited using ICTs. When we use computer and laptops we don't want to period off. When teachers give us problems we started to search in You Tube first and then in Google. Some of our friends started do solve the problem using excel. Firstly our teacher gives instruction to solve the problem using ICT tools especially in excel and GeoGebra and then give the similar type of the problem to solve. Most of us follow the teacher's instruction while some of us start to search in Google. He engaged students on searching mathematics relations, formulae, via

online. Some of our friend doesn't give attention toward teacher they enjoy their own interest in ICTs classroom (Interview transcription March 3, 2022).

From the above interviews I concluded that students became curious, motivated, focused and engaged in the class while teaching mathematics using ICT tools. Those students who are weak in mathematics and don't want to study it also become active while learning it through ICTs. Students desire increase to learn and practice more in mathematics. They were very positive toward mathematics learning through ICTs. Integration of ICTs in mathematics classroom has optimized the students' engagement in mathematics learning.

For class observation, I called my teacher participant T₃ and his headmaster at 1:30 p.m. a day before the observation. Both of them permit me to observe class. My participant T₃ allowed me to observe his first period. After that I met my headmaster for one day leave. He said "For leave you have to write an application." Immediately I wrote an application for leave and gave him. He approved my application. It was June 17, 2022. I wake up at 4:50 am. I finished my daily work and prepared for teaching. I leave my room at 5:30 for school to teach. I taught Nepalese Legal System of class 12 then left the school and headed to College. In college I taught two periods. They were statistics of BBS and Business mathematics of BBM first semester. Then I informed my college's principle that I would not teach last period.

It was 8 a.m. I went to my participant school K₃ to observe the class. I reached there at 9 am. Some students were in the ground. I asked them that why they were came so early. They answered me that there were coaching classes in school. One of the school staff informed me that head teacher was in the office. I reached to the office and met the head teacher. He offered me for tea but I denied that because it was

time of lunch. Then he encouraged me for my research work. Then I leaved the office at 9:15 am and went to the canteen. It was not so well managed. I took lunch there. While paying I found it was very cheap. I went in the ground and talked to some students. One of them was my student participant. I used to meet him usually. It was 9:30 when my teacher participant came to school. I met my teacher participant T_3 in ground. It was quite hot in the ground so he called me in the staffroom. I went to staffroom with him. We talked about teaching learning pedagogy. The bell rang at 10:00 a.m. It was pray time. All the students came to the ground. Teachers were also in the ground. They were guiding students to be in a straight line. At the last of the pray one of the student was called to give speech on climate change. She speaked for three minutes in English and all of the students clapped for her attractive speech. It was 10:12 a.m. when the pray end. All of the students went in there class in line. At 10:15 a.m. the bell rang. All of the teachers including my participant went to the class.

My teacher participant went in class 10. I also entered that class with him. He introduced me to the class. I went to last bench to sit. He sit on the first bench and opened his laptop and connect it with projector. One of the student stand on the bench and pushed a switch to switch on the projector. Then he demonstrated the objective of that day class by power point. It was "Students will be able to find lateral surface area and total surface area of square based pyramid." After that he showed some pictures of square based pyramid. He clarified what the dimensions of a square based pyramid called and what letters are used to denote its' dimensions. Then he opened power-point and showed its' surfaces by animations. Students were enjoying the class and excited by seeing those. They were counting the surfaces and were communicating to the teacher. Students draw the picture in copy and tried to derive the formula to find area of base, lateral surface area, and total surface area. At this time heads of all

students were down and their focus were on their work. After some minutes students were ready to show their work to the teacher. He checked some copies among of them 6 were correct. Now they were communicating to each other to find the formula and their mistakes. Teacher export and download the image on desktop and opened a new Microsoft word document. He inserted the picture there then he proved the formulae to find area of base, area of triangular face, lateral surface area and total surface area of a square based pyramid by using MS word. They were

Area of base of square based pyramid = a^2

Area of triangular face of a square based pyramid = $\frac{1}{2} \times a \times l$

Lateral surface area of square based pyramid = $2 \times a \times l$

Total surface area of square based pyramid = $a^2 + 2 \times a \times l$

Where a and l denote the length of base and slant height of a square based pyramid.

Students clapped for his work.

He opened a power point and showed to the students. There were some questions. Teacher asked students to solve the questions. One of the students told that he has already solved those questions. He explained those questions were on a page of Google and he had taken concept of pyramid through You Tube. Then teacher checked his work. All of the questions were rightly solved. Student added that he had already matched those solutions with the page where those questions were solved. Now many of students started to show their work to teacher. He checked some of them some were right and there were some mistakes in some copies then he clarified those questions. Then he cancelled all the apps which were running on his laptop then shut down his laptop. Suddenly the bell rang. One of the students stand on bench and pressed a key to switch off the projector. The teacher leaves the class room I also leave that class with teacher. I thanked my teacher participant and left the school.

From the class observation I found same result as the interview. When I observed mathematics class which was conducted in ICT lab, Students were using ICT tools like laptop, tablets and were following teacher's instruction. They were also solving the problems by using ICT tools. When I observed the mathematics class where teacher taught using projector and where there were lack of laptops students were focused on teacher's presentation and they used their paper and pen to derive the formulae and they also interact among themselves. They solve the problems even without instruction of teacher.

Furthermore I carried out a focus group discussion. For this I called six student participants but at the day of focus group discussion only four students came. When I asked them the question "Does your mathematics teacher teaches you using ICT tools?" All of the students answered "yes, our teacher sometimes teaches mathematics through ICTs." They also expressed that they feel happy and enjoy the learning mathematics by using ICT tools. Students said "Sometimes our teacher teaches mathematics in ICT lab and sometimes he teaches in our class using projector. While learning in ICT lab we use laptops, desktop and tablets. At that time we try to solve a problem on laptops, desktop and tablets as per instruction of our teacher. We also watch YouTube videos, Google search engines and also use various types of apps to solve the problems." One student added that they talk digitally and send the solutions each other. They become able to find the solution of the same problems in different methods. While their teacher teaches in the classroom by using Projector they became focused and learn the concepts. They understand the concepts and can solve the problems without help of teacher. They also discuss on the ways of solutions among themselves. One of the student mentioned that he prepares a lesson before his teacher teaches in the class. For this he use ICT tools at home. They desired for more ICT

integrated mathematics classes. They also demanded paper pencil less mathematics classroom.

From focus group discussion I found the same result as the result of interview and classroom observation. Students become curious to learn. They focus on the teaching learning process and solve the problems with excitement. They become self-motivated and actively participate in the classroom activities. ICTs increase collaboration among learners and encourage communication and knowledge sharing, provides quick and accurate feedback to learners, which leads to positive motivation, and allows pupils to focus on strategies and interpretations of answers rather than disputing (Becta, 2003).

ICTs encourage learners to be more engaged and participatory. (Dhakal & Sharma, 2016). From interview, classroom observation and focus group discussion I found three types of engagements of the students. They are engagement with teacher, engagement among students and engagement with ICT tools. Engagement with teacher includes the students' engagement includes the curiosities, motivations and other focused activities of the students expressed in front of the teacher. It also involves the interaction of the students with teacher. Engagement among students includes expression of stubbornness among the students. It means the activities to achieve the desire to learn among students. According to Akpan, Igwe, Mpamah and Okoro (2020) social constructivism is a collaborative form of studying based on interaction, discussion and expertise sharing amongst learners themselves. It also involves the transfer of understanding among the students. Engagement with ICT tools means self-motivation and self-deamination to learn. It includes the continuous rendezvous with the content and enjoy those activities. These engagements are overlapping. According to Heick (2022), high levels of engagement are characterized

by perseverance, prolonged inquiry, self-directed, playfulness with content and unprompted transfer of information. Teaching mathematics using ICTs creates high level of engagement of the students.

Demonstrating the Resources

According to Danielson (2011), a teacher's smart use of resources improves student learning. Demonstrating meaningful learning tools for students can enhance the learning interest, capability, and self-learning intent of the Students. In my study resources means the digital materials and digital resources of learning mathematics. If a teacher demonstrates the learning materials prepared by him/herself to the students then he/she can understand the concept clearly similarly if teacher shows the websites, pages or videos links then students can learn him/herself.

Regarding the demonstration of the resources my teacher participant T₃ expressed his view as

I have prepared slides and other required materials to display. While teaching in classroom I display that materials and then explain. Students listen my lecture without making any noise. I usually use ICT tools while giving concept rather than teaching problem solving but sometimes I prepare slides of long or difficult questions and show it in class. Sometimes I show the YouTube videos and the solution of questions from different websites and pages. I also show different figures with their label. It makes my teaching effective (Interview transcription March 9, 2022).

My teacher participant T₄ conveyed his view as

I always demonstrate different digital mathematical tools to give concept and attract students for learning mathematics. I show them the

PowerPoint documents which I have prepared. I also show them YouTube videos and online mathematical pages to learn and practice mathematics. I also show the list of many digital addresses of YouTube and pages where students can get the concept, problems, solutions and creative ideas of mathematics. Sometimes I teach students the way in which they can use those materials. I prefer to the line learn to know the address of knowledge (Interview transcription March 7, 2022).

My student participant S₂ explained "Our teacher demonstrates the formulae by using projector and explains them then we solve the problems in copy. If we ask any question then he solve that on white board (Interview transcription February 2, 2022)."

Similarly my student participant S₄ expressed his view as

My mathematics teacher seldom calls us to the ICT lab. In ICT lab he demonstrates YouTube videos that are very helpful for us. I can remember the day when my teacher demonstrated a video related to conic section. I understood the concept of eccentricity, length of latus rectum, Major axis, minor axis, symmetric nature and vertex of the parabola from that YouTube. Now he can easily draw the figure of parabola from the given information and can solve the problems of the parabola. He has also demonstrated us the videos of different types of curves like curve of $\sin\theta$, $\cos\theta$, and $\tan\theta$. I feel I understand the concepts from YouTube videos rather than the way in which my teacher teach in class by traditional method (Interview transcription April 10, 2022).

My student participant S₃ articulated his opinion as

Our mathematics teacher seldom uses ICT tools in our class. We feel happy when he teaches us by using ICTs. Sometimes he demonstrate us slides and sometimes he play you tube video. One main thing he does is that he demonstrates the various websites and the list of the apps and sites by which we can practice and learn. We know about Z-library, CDC library, NEB library, Khulakitab, booknet, etc because of our teacher. I have also downloaded some useful books from the website which he provided us. Similarly I usually watch you tube videos repeatedly recommended by him (Interview transcription March 3, 2022).

I found some of the teachers use ICTs as demonstrating resources. They prepare the teaching materials at home and then demonstrate through projector or by displaying the available screen. Some of the mathematics teachers also show the YouTube videos and animations of mathematical materials. They also present the list of the web pages and apps which are related to the content. They show how students can use those apps and web pages.

Moreover I observed two mathematics classes of two different mathematics teacher. They were T₄ and T₆. To observe class of my participant T₄. He permitted to observe his 6th period which was in class 9. I called his head teacher. He also allowed me to observe the class. I asked my headmaster for a day leave but he denied and said "Finish your all classes before break and go to observe the class." I agreed for it. On the day of class observation I wake up at 4 am. I finished my daily work and prepare for teaching. I left my room at 5:30 for school to teach. I taught Nepalese Legal System of class 12 then left the school and headed to College. In college I taught three

periods. There were statistics of BBS, Business mathematics of BBM first semester and Business statistics of BBM third semester. It was 9:30 a.m. when I finished those three periods. After that I went to my school. I reached there at 9:45 a.m. I went to the canteen and take lunch. It was 10 a.m. when the bell rang. I went to the stage and announced for the teachers to come in the ground and make lines. Then I started pity and ended those activates by national anthem. I thought all four periods and went to the school K_3 in when our break started.

I reached there in 5th period. A school staff informed me that head teacher was in the office. I went his office he welcomed me and told that my participant room is at the first floor of next building. The bell rang 6 times. I went to the class 9. I found my teacher participant was teaching. He was demonstrating PowerPoint slides. It was related to arithmetic sequence and series. It was his first slide. In that slide there were 7 examples of arithmetic sequences. Some of them were $2 + 4 + 6 + 7 \dots$, $1 + 5 + 9 + 13 \dots$, and $275 + 438 + 601 + 764 \dots$. He prepared students to guess next elements of those sequences. Then he showed next slide. In that slide there were explanation of common difference and n^{th} term of the sequence. After that he demonstrates some related examples. Then he gave four questions to the students to solve. The questions were

1. $2 + 4 + 6 + 7 \dots$ find the 5th, 6th and 10th term of the given series.
2. $1 + 5 + 9 + 13 \dots$ find the 5th, 7th and 10th term of the given series.
3. $275 + 438 + 601 + 764 \dots$ find the 5th, 6th and 12th term of the given series.
4. If common difference and fifth term of an arithmetic series are 6 and 27 respectively then find its first term.

He added students can use the app math solver and camera math if he/she have any confusion. He also demonstrates the apps where students can learn, practice and

play quiz of sequence and series. He demonstrate how students can play quizzes in the app mental Mathematics.

To observe next class, I called my participant T₆. She permitted to observe his 3rd period which was in class 10. I called her head teacher. He also allowed me to observe the class. I asked my headmaster for a day leave and he agreed for it. On the day of class observation I wake up at 4:30 am. I finished my daily work and prepare for teaching. I left my room at 5:30 for school to teach. I taught Nepalese Legal System of class 12 then left the school and headed to College. In college I taught three periods. There were statistics of BBS, Business mathematics of BBM first semester and Business statistics of BBM third semester. It was 9:30 a.m. when I finished those three periods. After that I went to the canteen where three teachers were discussing on the ways of cleaning Kathmandu. I also joined the discussion. Then I take my meal at 10:30 am. Then I went to a library and connect my laptop to internet and start to search some articles related to my research. I studied an article then I shut down my laptop and went to the school. I reached there at 11:45 a.m. I went to the head teacher. He welcomed me and informed me where my teacher participant is teaching.

I found teacher was teaching three dimensional figures through ICTs in class 10. There were 47 students sitting on their bench and one projector was fixed on the ceiling of the class. Teacher seemed to be confident with his laptop which was connected to the projector. Students were taking about the chapter and were curios to learn. Teacher was using GeoGebra to teach that. He had already prepared the materials for square based pyramids. She was showing and explaining about the surfaces of square based pyramid. She also showed that volume of square based pyramid is one third of the volume of cuboid if the base area and height of both geometrical figures is same by animation. It was shown by numerical values. When

he was increasing the height of the pyramid or cuboid the value of volume was seem to be increased and when she was decreasing them it was decreasing. The volume of square based pyramid seems to be one third at the same height as cuboid. He also demonstrate that if height of the square based pyramid is tripled than the height of the cuboid the volume of both objects are same. The animation was very attractive. He derived the formula to find volume, lateral surface area and total surface area of the square based pyramid then bell rang and teacher said "I will teach you the problems of square based pyramids on white board."

From classroom observation I found the similar result in many cases as the interviews. I found teachers are using ICT tools and showing various contents by PowerPoint, YouTube videos and by some mathematical applications. They are also showing the list of applications and address of websites and YouTube videos where students can learn and practice more. But they were not demonstrating the ways in which students can use those result was quite different than the interview.

When I rose the question "What are the materials demonstrated by teachers and how do they demonstrate those?" in FGD, one of student participantS₂ immediately replied that their teacher often show YouTube videos related to the content, figures, and formulae by PowerPoint (FGD transcription February October 2, 2022). All of the other students supported his voice. Another student participantS₃ voiced that their teacher demonstrate various figures with animations and also show the list of websites and pages where we can learn more (FGD transcription February October 2, 2022). He added that sometimes his teacher ask them to prepare digital material and present in the class (FGD transcription February October 2, 2022). One of the student participantS₅ objected his voice and said that their teacher shows YouTube videos, formulae and figures through ICT tools but don't demonstrate the

list of websites and related apps (FGD transcription February October 2, 2022). She added that her English, science and social teacher often ask them to prepare digital material and present in the class but her mathematics teacher has not told like that till now (FGD transcription February October 2, 2022).

From focus group discussion I found the similar result as interview and classroom observation. I found that teachers are demonstrating PowerPoint, You Tube videos, websites and different applications while teaching mathematics by using ICTs.

I found teachers are demonstrating two types of resources. First are self-constructed resources and second are ready made resources. Self-constructed resources include those resources which are prepared by teacher him/her-self. In my research I found teachers are using Power point and GeoGebra animations are self-constructed resources. Readymade resources are those which are available on websites or internet. They are mathematical apps, websites, online games, e-library etc. It seems quite hard to show all the pages, websites, videos, and self-constructed materials with in a period of 40 minutes so teachers are demonstrating self-created materials and You Tube videos in the classroom and showing the list of related websites so that students can learn him/her. Knowing where to get knowledge is more essential than knowing how or when to find it. (Downes, 2007).

Gamification of Learning Mathematics

Connect teaching learning with games or making it game by applying some rules is gamification of learning. When we apply this concept for mathematics teaching learning it becomes gamification of mathematics learning. It connects learning with the emotion of students and makes learning fun. It is about gaming strategy to improve learning and make it more engaging.

My teacher participant T₂ articulated "In class students want to ring the bell

fast but in computer lab they do not want to ring the bell (Interview transcription February 6, 2022)."

My teacher participant T₃ shared his view as

I have prepared 25 sets of multiple choice questions in Google form. The questions are both chapter wise and mixed. I always use those questions as game. I randomize those questions and send to students by fixing time. Students solve those questions and submit in time. Students get 2 golden points for one right answer and get 1 iron point for one wrong question. Total iron point is subtracted from total golden points that are called Final point. Each five final point makes diamond point. Students having highest number of diamond point gets prize after three games. I take students to ICT lab to play this game weekly. Game is finalized after three weeks. Sometimes I use begalileo.com, education.com, hoodamath.com, ipractice.com etc. for mathematical games (Interview transcription March 9, 2022).

One of the students S₁ conveyed "While we go to ICT lab we feel that we are playing rather than studying. We learn mathematics by watching videos and searching in Google. We feel happy to go to computer lab. We go to computer lab to play computer (Interview transcription March 7, 2022)."

My student participant S₂ expressed his view as

I was very weak in algebra. One of the teachers said to join an online self-learning class. I bought package. I started from factorization. For this I played a game like box setting. Gradually I become good in algebra. After that I started to attend quiz of algebra. At first I used to get only 5 to 10 marks out of 20 but now days I can get 15 to 20 out of

20. *Actually I learned algebra by playing (Interview transcription February October 2, 2022).*

My student participants S₆ conveyed his opinion as

Our teacher takes us in mathematics lab every Friday and shares a Google form of multiple choice question set. Then we solve all those questions within 30 minutes. We get our golden marks soon after submit the questions. Our final points are the point after 3 tests. A student who gets highest number of diamond point announced as winner and gets some prize. I have also been winner for that. I practice on online tests available on internet. I found most of the questions are similar as other online tests. One thing I noticed is that in our class our there was completion between only 5 students but now a days almost each students are competitor. This game has enhanced our mathematical capability (Interview transcription July 6, 2022).

From the interviews with my teacher participants and students I found teachers are using quizzes as mathematical game. Students are also emotionally connected with those games and are enjoying. Students are practicing mathematics with games. While observing ICT integrated mathematics classroom I found students were busy in searching mathematical solution of a problem. Two of the students were guiding other students and teacher was motivating to solve the problem.

When I expressed my desire to observe the class of gamification of my participant T₃. He immediately allowed me and call me for upcoming Friday at 10:15 am in ICT lab. I also called his headmaster for permission. He also allowed me for classroom observation. After that I met my headmaster for one day leave. He said "For leave you have to write an application." Immediately I wrote an application for

leave and gave him. He approved my application. It was July 15, 2022. I wake up at 4:50 am. I finished my daily work and prepared for teaching. I leave my room at 5:30 for school to teach. I taught Nepalese Legal System of class 12 then left the school and headed to College. In college I taught two periods. They were statistics of BBS and Business mathematics of BBM first semester. Then I informed my college's principle that I would not teach last period. It was 8 a.m. I went to my participant school K₃ to observe the class. I reached there at 9 am. Some students were in the ground. I asked them that why they were came so early. They answered me that there were coaching classes in school. One of the school staff informed me that head teacher was in the office. I reached to the office and met the head teacher. He offered me for tea but I denied that because it was time of lunch. Then he encouraged me for my research work. Then I leaved the office at 9:15 am and went to the canteen. It was not so well managed. I took lunch there. While paying I found it was very cheap. I went in the ground and talked to some students. One of them was my student participant. I used to meet him usually. It was 9:30 when my teacher participant came to school. I met my teacher participant T₃ in ground. It was quite hot in the ground so he called me in the staffroom. I went to staffroom with him. We talked about teaching learning pedagogy. The bell rang at 10:00 a.m. It was pray time. All the students came to the ground. Teachers were also in the ground. They were guiding students to be in a straight line. At the last of the pray one of the student was called to give speech on climate change. She speaked for three minutes in English and all of the students clapped for her attractive speech. It was 10:12 a.m. when the pray end. All of the students went in there class in line.

At 10:15 a.m. the bell rang. All of the teachers went to the class. My participant went to the ICT lab. I also entered ICT lab with him where students were

waiting for their teacher. There were exactly 25 students there. Each student has a laptop with them. He introduced me to the class. There was a smart board in front of the class. The teacher asked me to sit on a chair which was in front of the class. He opened his Gmail account where there were question sets. He said "We have just finished the topic money exchange and profit and loss in the class. So we play the quizzes related to that topic. He immediately shared a file to the group which was created in the messenger. It was a quiz file of Google form. He had fixed the time 30 minutes and 20 multiple choice questions. All of the students downloaded the file and started to solve. Students were solving the questions on the paper and hitting the one of the answer four answers. There was a pin drop silence in the class. When I watched the questions I found there were various levels of questions. There was a picture in one question. There seemed competition rather than co-operation. All students submitted the file within 30 minutes and rest were out of the game. Then the teacher watched their marks and immediately announced the name of first second and third students. The student who had given the correct answer of 17 questions was first similarly those who had given answers of 15 and 14 were second and third respectively. All of the students enjoyed that game."

From the classroom observation I found the same result as the interviews. I found teachers are using Google form tests and gamifying those tests by implementing some rules. Students are enjoying those games and increasing their ability with getting better points. Gamification does not directly affect learning but rather activates a learning-related behavior via a mediating or moderating process. (Zaric, Roepke, Lukarov, & Schroeder, 2021).

I found gamification in learning is at a very initial phase within our schools. Teachers are gamifying the learning of mathematics by using mathematics test tools but

students are practicing more online games that are increasing their learning capacity and understanding of mathematical concepts. Students are increasing their points not only in school but also at home. Gamification design favourably increases learners' engagement in gamified environments and those students' learning inclinations limit students' engagement. (Zaric , Roepke, Lukarov, & Schroeder, 2021).

Mathematics Learning by Apps

Mathematics can be taught effectively by using mathematics related apps like python, GeoGebra etc. According to Piage Tutt (2022), giving students the freedom to create and interact with information using their preferred digital apps has unexpected academic benefits. By engaging students where they are, utilizing technology in context to illustrate knowledge encourages experimentation and exploration. It also turns technology into a canvas on which students may solve issues rather than just exploiting it to find quick solutions. Students begin to consider themselves as knowledge creators rather than just consumers as a result of this process. Apps are self-learning digital tools. By use of apps students can understand, learn, practice and transfer mathematical knowledge.

One of the teacher participants T₄ conveyed his opinion as

I teach mathematics by using GeoGebra. It makes students to be clear about the concept of related topic. For example while I teach maxima and minima I give the concept of graph by using GeoGebra. I make students to draw the given inequalities in graph. I can denote the region of different inequalities by different colors by which students can understand easily and can find the common region easily and then vertex of common region after that they can easily find the maximum and minimum values. Similarly while teaching reflection, rotation and

enlargement I use GeoGebra animation. By which I can easily teach these topics and make students to understand. Students become very happy by watching those animations (Interview transcription April 12, 2022)

Another teacher participant T₅ conveyed his view as

I use GeoGebra to teach the geometrical concepts while I teach the concepts of area of parallelogram standing on same base and lying between same parallel lines are equal, area of triangles standing on same base and lying between same parallel lines are equal and area of triangle is half of area of parallelogram standing on same base and lying between same parallel lines. It makes me easy to teach by animation (Interview transcription May 15, 2022).

Another teacher participant T₆ expressed her view as

I use ICTs to teach statistics. I use excel to teach statistics. While teaching mean, median, mode, quartiles, standard deviations etc. While teaching mean, median, mode, quartiles and standard deviation of individual data I teach both direct and manual method and while teaching mean, median, mode, quartiles and standard deviation of discrete or continuous data I teach manual method (Interview transcription June 18, 2022).

One of the teacher participant T₃ articulated “ I use various types of mathematical apps like GeoGebra, python, and mathematics lab, word, excel, PowerPoint etc. but mostly I use power point and excel (Interview transcription March 9, 2022).”

One of the Student participant S_1 shared his view as

Our teacher mostly uses MS-word while teaching mathematics. He uses these apps to solve the problems of mathematics. Nowadays he is teaching trigonometric solution. For this he come to class with his laptop and then connect it projector then solve the questions we asked. He also call us to solve the problem on white board. Our teacher use laptop but we have to solve the problem on white board by writing with marker. Sometimes he uses PowerPoint, excel and GeoGebra. I remember that he has taught us parabola by using GeoGebra which was very interesting." (Interview transcription January 2, 2022)

One of the students S_2 conveyed "Our teacher teaches mathematics in brilliant way. Sometimes we go to ICT lab to learn mathematics at that time our teacher explains mathematical rules by showing Power Point, Our teacher makes us to solve the statistics problem by using Excel and sometimes he shows us the GeoGebra presentation (Interview transcription March 7, 2022)."

From interviews with teachers and students I came to know that teachers are using office applications like MS-word, Excel, and Power Point mostly. They are using python, GeoGebra and mathematics lab while giving concept of the content. Furthermore, I have carried out observations in mathematics classes.

For class observation I called my teacher participant T_2 and his headmaster at 2 p.m. a day before the observation. Both of them permit me to observe class. After that I called my headmaster for one day leave. He said "For leave you have to mail an application." Immediately I typed an application for leave and send to my headmaster. He approved my application. It was June 12, 2022 I wake up at 4 am. I finished my daily work and prepare for teaching. I leave my room at 5:30 for school to teach. I

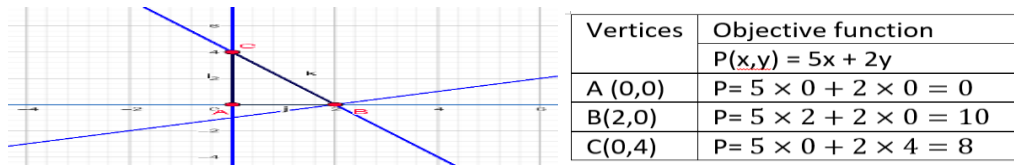
taught Nepalese Legal System of class 12 then left the school and headed to College. In college I taught three periods. There were statistics of BBS, Business mathematics of BBM first semester and Business statistics of BBM third semester. It was 9:30 a.m. I went to my participant school to observe the class. I reached there at 10:15 am. I knocked the gate school staff gate keeper came there and opened the door. It was just end of the pray when I entered in the school. Head teacher met me in ground. After a small conversation he showed me the staffroom. I went to staffroom my teacher participant T₂ was on laptop. When he saw me he requested me to take seat near his chair. I sat there and watched what he was doing on laptop. I saw he was preparing for teaching today. He informed me that he wants me to observe his third period but it was first period. I decided to observe the ICTs availability in that school. I talked to the vice principal madam for it. She called a student and told her to take me in ICT rooms. I went with him to ICT lab. I found It was well managed there was a smart board and three other screen. Desks and chairs were well managed and laptops and tablets were in a trunk. Each of the ICT tools was connected with the charging device. He informed me that there were 35 laptops and 25 tablets in that case. After observing that ICT lab he take me to another ICT lab which was on third floor. It was less facilitated than the previous one. There were 10 benches and one smart board. There were 25 laptops in case and all of those were connected with charging device. The bell rang and it was break time. I came to ground and talk to the students of the class 10D in which class I had to observe. They informed me that there is a projector in that class and his teacher teaches them with the use of projectors. The bell rang again after 15 minutes. It was the time of class observation. Students informed me that their teacher called him in ICT lab. I went to ICT lab which was located at ground floor with them. One of them had the key of the case where the laptops were. Each student

takes either laptop or tablet and sit on the chairs. I also sit on a chair which was at middle of the lab. Teacher came after 5 minutes. All the students and I stand and say good afternoon to the teacher. Teacher had nothing with him. He went in front of the class and run smart board then he turn on a special laptop which was only for teachers. He made to display every activity which he was doing on laptop on smart board. All of the students and me were able to see every activities of teacher which was he conduction on laptop. Firstly he opened his Gmail account then he download a file from the Gmail. It was his digital teaching materials. At this time students were talking to each other and there was a little bit noise in the class. He showed a slide and revised the inequality and graph. After this he clarified that the objective of that day was to find the maxima and minima of an objective function where inequalities were given. For this he showed a question "Maximize $P(x, y) = 5x+2y$ subject to the constraints $2x + y \leq 4$, $x - 2y \leq 2$, $x \geq 0$, $y \geq 0$." Then class became calm. Teacher opened MS word and copied this question there. He clarified the objective function, and constraints.

Objective function: $P(x,y) = 5x+2y$

Constraints: $2x + y \leq 4$, $x - 2y \leq 2$, $x \geq 0$, $y \geq 0$

He asked students to draw the graphs of the given inequalities. Student opened geogebra and drew the graph of the inequalities within 5 minutes. Teacher also drew the graph of the inequalities by using different colors in geogebra. He clarified that the common region of all inequalities is called feasible region and he darkened the feasible region and highlighted the vertices of feasible region. Then he pointed the vertices of feasible region and used them to find the maximum value of the objective function by making table in MS word. The maximum value was 10 at point (2,0). He also explained that similarly the minimum value can be found by the same table.



Soon after he finished this he gave a question to the student to solve. The question was "Minimize $f(x, y) = 10x + 15y$ subject to the constraints $x - y \geq 1$, $x + y \geq 4$, $x \geq 0$, $y \geq 0$." "Students solve it within 5 minutes. One of them presented it. Suddenly the bell rang and the teacher said goodbye to the class.

While observing class I found that teachers are using MS-word, PowerPoint, and Excel for teaching mathematics. In interview they claimed that they are using many mathematical apps like GeoGebra, python, and mathematics lab but by class observation I found teachers are using only GeoGebra of mathematics app. Students were also solving the problem themselves on laptop. They were focusing on the process rather than answer. Which was very important for the students to understand? Students would use technology to concentrate on problem-solving processes rather than on calculations related to the problems (Ittigson and Zewe, 2003).

There are varieties of apps that a teacher uses in mathematical classroom while teaching mathematics using ICTs. Most of the apps are office based apps. GeoGebra is the only mathematical app used by teachers in classroom. But students use many android mobile based apps to solve the problems and to practice mathematics. Students uses math solver, mental math, math test, camera math etc. apps. It seems that students use more mathematical apps than teacher. Teacher uses laptop based apps more whereas students use mobile based apps more. Downes (2007), stated that knowledge changes moment to moment and is contruced. New technologies are replacing traditional teaching learning process.

Teaching Mathematics during the Pandemic Covid-19

It was 2020 when the world was suffering from a pandemic called Covid-19.

There were lockdown about all over the world. About all of the educational and non-educational organizations were shut down. In Nepal most of the schools had stopped their teaching learning activities but at that time some schools were teaching their students online. They were using Zoom, team, Google classroom etc. Online teaching learning was common at that time.

One of the teacher participant T₂ conveyed his view as

I start zoom then give the zoom id and password to the students through messenger after that I fix my mobile so that my white board can be covered then I teach my students on physical white board which I have at home. Students can easily see all those. Students ask me the question where they don't understand and I try to clarify that. While teaching online I said students to on their camera and mute their device. It is like face to face learning but a little difficult (Interview transcription February 6, 2020).

My another teacher T₃ articulated his opinion as

I use laptop to teach my students in virtual mode. I open team in my laptop to teach mathematics. I share pictures and my power point documents. I share white board when I have to write or solve problem. Sometimes I evaluate my students by using Google forms. To evaluate I give both multiple choice questions and subjective questions. For multiple choice questions I give them the result (marks) within five minutes. For subjective answer question students send me their answer in my email by taking pictures of their answer. I download all those answer and check them by using an app which facilitates me the virtual pen then I send them the marks with proper comments. I think e-

teaching is more effective than the traditional teaching." (Interview transcribed, September 11, 2020).

Another teacher participant T₄ had same voice as T₃. He explained "I use tablet to teach my students. It has been very easy to write on digital white board with its pen. I show power point slides, use MS-word, excel, GeoGebra etc to teach."

One of the students S₁ articulated "Our teacher teaches mathematics on white board and show it through team. We connect him through mobile phone"

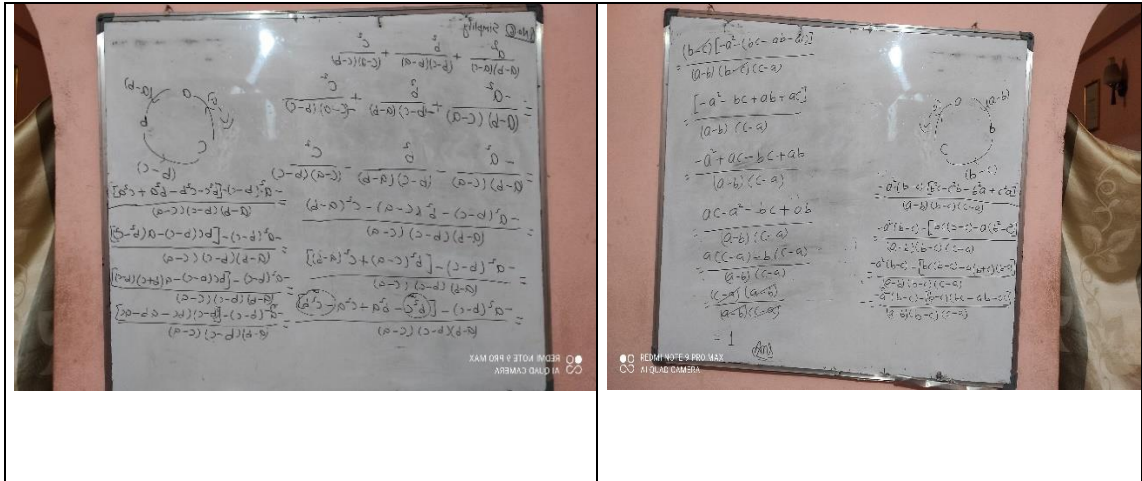
Another student participant S₂ shared his view as

Our teacher teaches mathematics on team. He uses white bard, YouTube videos and other power point documents to teach us. He takes online exam and gives us feedback. He conforms for our camera on. He gives us home works. We solve the problems and send in Gmail. Sometimes he makes us to prepare Power Point document and let us present online. Most of us join him with android mobile. Once he ordered me to present about matrix. I prepared slides on my mobile and on the power point which I have downloaded then presented that (Interview transcribed, September 14, 2020).

From interviews with teachers and students I found there was variety in the digital tools used by teachers but most of the teachers and students were using android mobile for learning. Smartphones also have various advantages in terms of efficiency, such as using less data than computers. Practically all teachers use cell phones as a communication tool, most teachers utilize them for Internet access. (Sri, Elfira, Ely, Luluk, Faruq, Mona, 2022). Some of the teachers were using his cell phone as video camera to teach where as other were using its various tools in creative ways. They were using various types of apps like zoom, team, Google class, whiteboard, videos

and other related to apps to teach.

For classroom observation I called T₂. It was 12 September when I called him. He allowed me to observe his class on 13 September 2020. On 13 September 2020 I wake up in morning at 7 am I became fresh at 7:30 am, then I taught Business statistics of the BBS online. Then I take my lunch and went to his house. It was 10 am when I reached at his house. He welcomed me at his home and take me at the room from where he was teaching. We both were maintaining social distance and had put mask on our face. There was two chairs one desk and one big whiteboard. At 10:10 am he called his son. His son came in the room with a mobile stand then take his father's mobile and fixed on the stand and went out from that room. He opened team in mobile then send the link to the messenger group of class 10. Students gradually came in the online class. They had opened the camera and muted the mobile. Teacher started the class. He firstly called some students with his name and asked for yesterday's homework. They replied that they had completed their homework. Then he said today we will do next question of algebraic fraction. Then he wrote a question $\frac{a^3}{(a-b)(a-c)} + \frac{b^3}{(b-c)(b-a)} + \frac{c^3}{(c-a)(c-b)}$ and asked students to solve this. Students tried to solve. We were clearly seeing that they were trying to solve this. After 10 minutes each students were ready to show their answer but all of them had made mistake. Then teacher started to solve this question on the physical whiteboard which was in his room. Firstly he gave the concept of cyclic order for which he asked that we have to make the denominator like (a-b), (b-c), (c-a) for this we have to change (a-c) into (c-a), (b-a) into (a-b) and (c-b) into (b-c) by taking minus as common. Then he solved this question on the white board.



Students said that their other teacher has sent the link in messenger. Then my teacher participant say good bye to students and give some question as homework.

For class observation of another teacher I called my teacher participant T₄. When I asked him for classroom observation firstly he denied. After a week I asked again for classroom observation at this time he became ready with a condition that he will take the class from home. I agreed. It was 5 October 2020, I wake up in morning at 7 am I became fresh at 7:30 am, and then I taught Business statistics of the BBS online. Then I took my lunch and started to study some articles related to my research topic. It was 11 am when I heard a sharp horn of motorbike. I came to my balkani. It was my participant's bike horn. I called him at first floor. I took him in my room. He firstly sanitized sofa and then sit there. I offered for tea but he denied. It was 11:15 am when he started his class. For this he started his laptop and click on zoom. Then students joined his class themselves. He asked students "What we studied yesterday?" Students replied mean of the continuous data. That day he was teaching median of the continuous data. For this he click on share button and then click on screen. He opened MS-word then write the formula to find median. It was *Median class* = $\left(\frac{n}{2}\right)^{th}$ term,

$Median = l + \frac{\frac{n}{2} - c.f.}{f} \times i$ Where $n, l, c.f., f,$ and i stand for sum of the frequencies,

lower limit of the required interval, cumulative frequency up to upper interval and interval and explained it. Students copied these formulae. Then teacher cut MS-word and opened MS-excel. He asked a student to share a question so that he can solve that. One of the student asked for access to share the question of his text book. Teacher gave access. Student shared a question. It was: Find the median of the following data

C.I	10-20	20-30	30-40	40-50	50-60
Frequency	5	7	6	7	5

For next class room observation I called my teacher participant T₄. He allowed me to observe his class. On 13 October 2020 I wake up in morning at 7 am I became fresh at 7:30 am, then I taught Business statistics of the BBS online. Then I take my lunch and went to his house. It was 1 pm when I reached at his house. He welcomed me at his home and takes me at the room from where he was teaching. We both were maintaining social distance and wearing mask. At 1:15 pm he started his class. He opened his laptop and connects students on team. He was teaching solution of trigonometric equation for this he shared the screen and opens the MS-word then he started to give some concepts. It was verbal. Then he typed a question from the text book. It was: Solve the following trigonometric equation $\cos A = \cos (\pi - 2A)$. Then he started to solve

$$\cos A = \cos (\pi - 2A)$$

$$\text{or, } A = \pi - 2A$$

$$\text{or, } A + 2A = \pi$$

$$\text{or, } 3A = \pi$$

$$\text{or, } A = \frac{\pi}{3} = 60^\circ$$

Then he gave a question to the students to solve. It was $\cos \theta = \sin 2\theta$. Many of the

students send the solutions. Students were writing on their copy and sending it by taking photo. He checked some of those, most of the students have done write. Then he typed next question $4 \cos A = 3 \sec A$ and asked students to solve. Some students tried it but most of the students asked teacher to solve this then teacher solved it as follows:

$$4 \cos A = 3 \sec A$$

$$\text{or, } 4 \cos A = 3 \cdot \frac{1}{\cos A}$$

$$\text{or, } 4 \cos^2 A = 3$$

$$\text{or, } \cos^2 A = \frac{3}{4}$$

$$\text{or, } \cos^2 A - \frac{3}{4} = 0$$

$$\text{or, } \cos^2 A - \left(\frac{\sqrt{3}}{2}\right)^2 = 0$$

$$\text{or, } \left(\cos A + \frac{\sqrt{3}}{2}\right) \left(\cos A - \frac{\sqrt{3}}{2}\right) = 0$$

<p>Either</p> $\cos A + \frac{\sqrt{3}}{2} = 0$ $\cos A = -\frac{\sqrt{3}}{2}$ $\cos A = \cos (180-30)$ $A = 150$	<p>Or</p> $\cos A - \frac{\sqrt{3}}{2} = 0$ $\cos A = \frac{\sqrt{3}}{2}$ $\cos A = \cos 30 \text{ or } \cos 330$ $A = 30 \text{ or } 330$
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After this teacher gave some questions as homework.

From classroom observation I found some of the teachers were using their cell phone or laptop as teaching tool. Teachers who were using their cellphone as teaching device using it as video camera.

I found most of the teachers and were using his/her cellphone for teaching learning. Some of the teachers were using their cellphone as video camera only where

as some of them were using it in various ways. Some of the teachers were using their laptop and pin touch tablet. The highly prefer tools have laptop/ desktop computer, multimedia projector, cell phone and software tools like internet, email, office program and related apps like Moodle (Sri, Elfira, Ely, Luluk, Faruq, Mona, 2022). I found most of the teachers were using Microsoft office programs rather than typical mathematical apps. Team, zoom and Google class were most famous apps for class. Some of teachers were using digital whiteboard to solve mathematical problems. It was very cheerful for some of the teachers to teach through ICTs but for some teachers it was not so good. Some students were learning mathematics effectively but some were not. But one common thing is that online teaching learning mode was increasing. Teachers were learning ICTs and students were learning both ICTs and content. At the stage of Covid-19 learning through ICTs has been accelerated.

Chapter Summary

Teaching and learning mathematics through ICTs seems increasing after Covid-19. Most of the teachers use office programs like MS-word, Power-Point, MS-excel to teach mathematics. Some of the teachers use GeoGebra. ICTs seem to be just a demonstrating tool in most of the mathematics classes. But use of ICTs in mathematics classes makes students proactive. They seem to become active and curious while a teacher teaches mathematics through ICTs. Using ICT tools in mathematics classroom is itself being gamification of mathematics. Some of the teachers use quizzes of mathematics which makes mathematics fun. Use of ICTs in mathematics teaching learning increasing student's engagement and gradually digitalizing learning process.

Chapter V

OPPORTUNITIES OF ICTS INTEGRATION IN MATHEMATICS

CLASSROOM

The second objective of my research was to explore the opportunities of ICTs integration in mathematics classroom. To fulfil this objective I used the tools were in-depth interview with teacher, head-teacher, student, and expert participants; classroom observation of my teacher participants; and focus group discussion with my student participants. I have explored various opportunities of ICT integrated mathematics classroom. This chapter includes the detail analysis of opportunities created by ICT integrated mathematics classroom. I have developed some themes to describe the opportunities created by ICT integrated mathematics classroom. Motivation to learn mathematics, saving time and cost to learn mathematics, availability of finding learning materials, students' and teachers' interaction, opportunities of self-learning, student friendly environment in classroom, and opportunity of teaching learning and earning are the themes under which I have analyzed the opportunity of ICTs' integration in mathematics classroom.

Motivation to Learn Mathematics

Motivation is the drive for the students which accelerate the speed of learning to get better knowledge and enhance once capacity. It is a catalyst for students to increase the rate of learning. Motivation is the driving force that drives people to act in order to achieve their goals. There are two sorts of motivation: intrinsic (or internal) motivation, and extrinsic (or external) motivation (Waters; 2002). Extrinsic drive originates outside of the individual and frequently includes external incentives such as prizes, wealth, social prestige, or admiration whereas intrinsic motivation is internal and emerges from inside the individual, such as finishing a difficult

crossword puzzle just for the satisfaction of solving a problem (Tranquillo and Stecker, 2016).

One of my teacher participants T₃ shared his view as

ICTs integration in mathematics teaching learning motivates me to perform better and learn day by day. Due to ICTs integration in mathematics classroom I became able to teach more effectively and joyfully. Yes, I have to prepare more but after that when I use it in classroom the students became much focused and curious. These motivate me to teach through ICTs (Interview transcription February 2, 2022).

My another teacher participant T₄ claimed "There is no other way of teaching mathematics through ICTs in future so every mathematics teachers must be prepared to teach mathematics through ICTs (Interview transcription February 2, 2022)."

My next teacher participant T₅ interpreted his opinion as

I am positively motivated to teach mathematics using ICTs in classroom. To teach mathematics in the classroom I prepare at home. When preparing lesson plans with the help of ICTs. I learn some thing daily. When teaching in class with the help of ICTs I face a lot of problems that are because of lack of proper knowledge of ICTs but I solve all those problems which increase my ICTs technical knowledge. Another thing is once I prepare my teaching materials I can use it for several times in several classes (Interview transcribed, September 10, 2020).

My one more teacher participant T₂ expressed his experience as

In teachers training one of the trainers used to demonstrate his material through ICT tools. I felt his presentation was better than others because of ICTS integration. The entire trainee adored and enjoyed his session rather than others. At that time I intended to teach my students using ICTs but I was very poor in ICTs. Even I was not able to open and shut down the laptop but I was intended to use ICTS in my classroom. For this I buy a laptop and connect internet at my home. My son who was just of 10 years teaches me to start and shutdown the laptop. I practice MS- paint to my mouse stability. Then I started to type in MS-word. In MS-word I typed various things in English gradually I become able to type in Nepali and as my subject demand I became able to use equation in MS-word. I started to type mathematics question myself. After that a projector was installed in my school. Our English teacher started to teach student through projector. I become curious about that and I also want to teach through projector but at that time I were not able to teach through projector. Our English teacher help me to prepare power-pint documents and use the projector. I used to use projector once a week. Once our mathematics council help a program for ICT integrated mathematics classroom. At that training I learn to use GeoGebra. Now a days I am using GeoGebra to teach mathematics. YouTube, Google etc. also help me to learn the skills of mathematics teaching with the help of ICTs. Now my laptop has been old but my intention to learn ICTS is still fresh. Actually I enjoy the moments when I teach mathematics through ICTs

(Interview transcription February 9, 2020).

My next teacher participant T₅ shared his experience as

It has been easy to motivate students to learn mathematics. I give basic concept with the help of ICTS in attractive way. They become very happy and understand the basic concept. I also demonstrate the YouTube to motivate students (Interview transcription May 15, 2020).

ICT integration in mathematics teaching and learning motivates teachers and students to improve and learn. This allows teachers to teach more effectively and happily. Students become much more attentive and interested when teachers teach through ICT. This inspires teachers to teach with ICT. Teachers are enthusiastic about using ICTs in the classroom to teach mathematics. They prepare at home to teach mathematics and learn something new, and they overcome difficulties caused by lack of ICT understanding. Additionally, they can reuse their teaching materials in several classes. This boosts their ICT technical knowledge. It has been simple to persuade students to study maths. Teachers present simple concepts in an appealing manner using ICTS. Students overjoy and understand the main notion. Teachers frequently show YouTube videos to pupils to stimulate them. These activities motivate teachers and students to learn mathematics.

When I communicated to the students on this issue. My first participant student S₂ conveyed his view as

Our teacher always informs us what he is going to teach tomorrow. I always prepare that chapter before our teacher teaches. For this I search in YouTube for the concept and then start does me. I ask teacher for what I don't understand. So that learning mathematics has been easier than the previous days (Interview transcription February

3, 2020).

My next student participant S₁ expressed his opinion as

When our teacher use ICT tools to teach us we became very excited. We understand the concept by ICT tools rather than tradition lecture method. We can see and analyze ourselves. After understanding the concept we can easily derive the related formulae and solve the problem. Sometimes we don't need our teacher's help within a whole chapter (Interview transcription January 2, 2020).

My another student participant S₃ expressed his opinion as

I am new student of this school. I was very weak in mathematics when I was in my previous school. I did not understand what teacher was teaching in class. He always teaches us by tradition lecture method. I used to copy the solution from guidebook for homework. I used to get very poor marks or grade in mathematics. I used to think that mathematics is not for me. I have to just rote some solution of the question which are important for examination. When I came to this school our teacher advised me to prepare the basic concept first. For this I started from addition, subtraction, multiple and division of both arithmetic and algebra and for geometry I started from point and line. For practice I used different pages and You Tube videos. About practicing a week I started to understand mathematics. Learning through ICTs motivated me to learn more and myself. I started to enjoy mathematics. Our mathematics teacher also focused me and use ICT tools to teach. My mathematics is improving gradually. Now I am not excellent but good in mathematics. Actually my teacher and ICT tools

helps me to improve my mathematics (Interview transcription April 15, 2020).

From the interviews with students I came to know that they become tremendously enthused when teachers use ICT tools to teach them. Students grasp the subject through ICT tools rather than the traditional lecture style. Students may observe and assess themselves. They may readily deduce the associated formulas and solve the problem if they comprehend the notion. Sometimes they don't require our teacher's assistance for an entire chapter.

In fact teaching and learning through ICTs has positively motivated teachers and students. They are using ICTS in mathematics teaching learning. The motivations are seem to be intrinsic rather than extrinsic. Teachers and students become emotionally connected with teaching learning while teaching mathematics through ICTs. Teachers fell satisfied and students enjoy the learning process. Teachers and students became goal oriented, finish difficult problems and get satisfied by solving problems. In this line Sze, Sheung-hoi, and Kevin (2004) found the usage of ICTs in education improves students' study motivation.

Saving Time and Cost to Learn Mathematics

Time and costs are important factors of teaching learning. Increment in time and cost of learning can decrease the outcome of mathematics teaching learning and Decrement in time and cost of learning can increase the outcome of mathematics teaching learning because if a student have to spent a lot of time and money to learn something then he/she wouldn't want to do that and if a student have to spent a less time and money to learn something then he/she would want to do that.

One of my teacher participants T₃ expressed his opinion as

I used to spend about an hour daily to prepare lesson plans for

teaching. I am using ICT tools from a year ago. In previous year I spent a little more time to prepare materials to teach but now I am using those prepared materials. I can show many slides with in a class. I can teach more by using previously prepared materials. It has saved my time (Interview transcription March 9, 2022).

My another teacher participant T₂ explained his opinion as

ICTs in mathematics teaching save time and cost. We can make students to show the problem of statistics in excel. Students can draw figures of simple bar diagram, multiple bar diagram, submultiple bar diagram, pie charts, histogram, ogive, parabola, hyperbola, ellipse, circle etc. in few minutes. Students can solve lengthy mathematical problems in short period (Interview transcription February 6, 2022).

My teacher participant T₄ articulated that they can download books, teaching materials, and also can take training and learn from videos these activities save their time and money (Interview transcription April 12, 2022).

My next teacher participant T₃ expressed his view as "I used to buy a lots of books to prepare but now a days I am using ICTs in mathematics learning. I can download sufficient books and can prepare by using many Google pages, You Tube and other applications. So it has saved my cost of learning (Interview transcription March 9, 2022)."

ICTs in mathematics education save both time and cash on teaching and learning. Teachers might require pupils to display a statistical problem in Excel. They can make simple bar diagrams, multiple bar diagrams, submultiple bar diagrams, pie charts, histograms, ogives, parabolas, hyperbolas, ellipses, circles, and other figures in a matter of minutes. They can answer complex mathematical problems in a short

amount of time by using ICT tools. This process save the money which would be spent on the buying papers and other tools where as it also save time because they can show mathematical figures on screen. Similarly, it has reduced the cost of buying books because teachers and students can download many online books for free.

When I communicate on this issue with my student participants. One of my student participants S₃ expressed his view as

Mathematics through ICTs save our time. We can solve the problem and find answer in a few minutes. We can watch videos and can search Google to find appropriate solution of a problem or to get concept. We don't have to go to teacher. We don't have to take tuition and extra classes by paying a lot of money. This process saves our time and money (Interview transcription March 3, 2022).

ICTs in mathematics save students' time. They can solve the problem and locate the solution in a matter little time. They can watch movies and search Google for relevant solutions to problems or concepts. They are not required to attend class. They are not required to pay for tuition and additional lessons. So, ICT integration in mathematics classroom saves time and cost of students.

From in depth interview with my participants I came to know that teachers and students believe that Use of ICTs in teaching learning mathematics saves time and cost. The use of ICTs improve the productivity while reducing costs and saving time (Anderson, 2022).

Availability of Finding Learning Materials

Many researches shoes that availability of proper learning materials are helpful in effective teaching learning. Students can clarify their dought with the help of learning materials in no time. The availability of sufficient, high-quality

instructional resources for instructors and educational supplies and materials for students, including textbooks, is a crucial determinant in teacher satisfaction and motivation, as well as educational results (UNESCO, 2014). Since we can find a lot of online learning materials on ICTs, we can say that there is availability of learning materials.

When I interviewed on this issue one of my teacher participant T₂ articulated as

I have been teaching for several years. I used to teach only the contents which are given in the book. I used to solve the questions by the methods which were shown in the examples of the book. After using ICT tools I can find a lot of materials related to the course content. I can show several methods of solving problems. I think knowledge were captured in past but now it has been exposed due to ICTs (Interview transcription February 6, 2022).

My another teacher participant T₅ conveyed his opinion

Now a days I use GeoGebra to clarify the concept of conic section. Students can visualize the concept of intersection of plane and the cone. I can easily understand the concept of parabola, hyperbola and ellipse (Interview transcription May 15, 2022).

My teacher participant T₆ voiced "I used to prepare to teach by using textbook only. But now a days to prepare for teaching I search on Google, z-library (Interview transcription June 18, 2022).

Teachers can find a lot of things connected to the course of a subject after using ICT tools. They can demonstrate different approaches to issue resolution. They believe that knowledge was captured in the past, but now it has been revealed as a

result of ICTs. At past they were preparing and teaching only through text books and nowadays teey they can get a lots of teaching learning materials on ICTs.

One of my student participants S₂ conveyed his opinion as

I can learn more than my teacher teaches with the help of ICTs. With the help of ICT tools I can prepare mathematics myself. I usually do my work before my teacher asks me. I use ICTs to learn mathematics and prepare before my teacher teaches.” Another student said “I can learn mathematics and exchange materials with my friends through ICTs. Sometime my big brothers who live in America help me in solving mathematical problem. I always search my problems in Google and try to understand. I usually watch YouTube videos to solve or understand the concept (Interview transcription February 6, 2022).

My another student participant S₃ explained

I am in class 10 now. When I was in class nine I got just low grading in each terminal examination. One day I found three question sets in Facebook page. I started to solve all those questions. I watched online solutions and take ideas from You Tube. I became able to solve all those questions. Luckily in final examination same types of questions I practices were asked in examination. I got grade A. So nowadays I am practicing mathematics using ICTs (Interview transcription February 6, 2022).

My next student participant S₄ voiced "In summer vacation I prepared all of my syllabus. I take a online mathematics class. In that class I understand the concept and I solved all the problems of my book my-self (Interview transcription April 12, 2022)."

From the interviews with students I came to know that they found a lots of learning materials on ICTs. They can download books, understand the concepts through videos and explanation available on ICTs.

From the above information of my participants I came to know that ICTs have create vast opportunity for both teachers and students. By using ICT tools teachers can get better opportunity for training. Students can get better axes to some reputed colleges. Students can collaborate among themselves and other to solve problems. By using many apps students can be creative and can derive new knowledge. Whereas teachers can get new and updated knowledge and can apply in teaching and learning. So it can be said that use of ICTs in teaching and learning mathematics create better opportunities for both teachers and students in knowledge gaining and creating. Some of the advantages of utilizing ICTs at technical college include making teaching and learning more engaging, assisting teachers in staying current, improving the quality of work of both teachers and students, and gaining access to more knowledge (Apagu & Wakili, 2015).

Students' and Teachers' Interaction

Classroom interaction refers to the interaction in the classroom between the teacher and the students, as well as among the students (Tsui, 2001). Interaction between teachers and students helps to mobilize the classroom environment (Sun et al., 2022).

One of my teacher participants T₃ articulated his opinion as

When I teach mathematics using ICTs students become very happy and interactive in the classroom. Students become very cooperative while teaching through ICTs. They themselves start to on the projector, give me the wire of projector to join with my laptop. Some of the student

helps me in operating ICT tools. I have also created a fearless environment in the classroom. While teaching students raise many questions in the classroom. They frequently talk to me and share his/her views (Interview transcription February 6, 2022).

My next teacher participant T₂ expressed his view as

We mathematics department meet together online at 7 pm at least once a week. At that time we discuss on the various topic of mathematics and the way we are using to teach. Once I remember dhur, kattha, bigaha, daam, aana, and ropani etc was newly introduced in the course of class 9. At that time we were very weak to measure land practically but one of our friends had knowledge of that. He guided us online line and give us idea of converting the sq. feet and sq. meter into dhur kattha, bigaha, daam, aana, and ropani. He also give us idea that while measuring the area of irregular shaped land we have to break it into several triangles and then find the area of each triangle and add all the triangle (Interview transcription February 6, 2022).

My teacher participant T₄ enunciated “We mathematics teachers discuss on various mathematical problem on zoom. We enter change our teaching methods, experiences and mathematical problems on ICT tools (Interview transcription April 12, 2022).”

When teachers use ICTs to teach mathematics, pupils become highly pleased and participatory in the classroom. When using ICTs to educate, students become extremely cooperative. Some students assist teachers in using ICT gadgets. In the classroom, teachers have also fostered a courageous environment. Many questions are raised in the classroom by pupils while they are being taught. They regularly

converse with teachers and give their perspectives. Further more teachers also discuss on various mathematical problems on zoom and exchange their teaching methods and experiences.

When I raised this issue in front of my first student participant S₂. He expressed his view as

When our teacher teaches mathematics in the ICT lab we students ask some questions to teachers but most of the problems solve ourselves by helping each other. We frequently talk to each other to operate the ICT tools. Sometimes our teacher gives problems of mathematics to solve. We all try to solve our self. We help each other. If can't we search on internet. We also share those solutions. At last we interact on the problem and create short and sweet method to solve (Interview transcription February 2, 2022).

Moreover my student participant S₃ explained his view as

I was very weak in mathematics. After entering class 10 we have a team of 3 of three students. One of us is quite talent in mathematics. We do our home works by interacting to each other on messenger. Now a days he guide us for mathematics on messenger. My mathematics is in progress (Interview transcription February 6, 2022).

Likewise my student participant S₁ added his opinion as

I was absent while teaching money exchange in class but after interacting online with friends I can do chain rule, devaluated, revaluated etc. problems. At least I can solve all the problems of our book (Interview transcription February 6, 2022).

When a teacher teaches mathematics in the ICT lab, students ask questions,

but most of the problems are solved by assisting one another by them. Students regularly communicate with one another in order to use the ICT tools. Sometimes the teacher assigns mathematical problems to the students to solve. They are all attempting to solve themselves. They assist one another. If they are unable, they conduct an internet search. They also discuss the solutions. Students collaborate on the topic and generate concise solutions.

According to Akpan, Igwe, Mpamah and Okoro (2020), social constructivism is a collaborative form of studying based on interaction, discussion and expertise sharing amongst learners themselves. Use of ICTs creates great opportunity of interaction. Through ICTs students can interact among themselves and can interact with teachers and can learn mathematics easily. Teachers also can interact among themselves for several problems. Students can interact with the students and teachers of other school and exports as well. Similarly teachers can update him/her by interacting with other teachers and experts. Downes (2007), recognized that technology is an important element of the learning process and that our continual connectivity allows us to make choices about our learning. ICTs upturn communication among students and teachers (Tsui, 2001).

Opportunities of Self-learning

Self-learning is a method of learning in which the learner takes an effort to recognize their own learning requirements, create learning goals, locate appropriate resources, and assesses their own knowledge (Athuraliya & posts, 2020). ICT tools are self-learning tools. Now a days it has been main source of knowledge. Students can search their many things in Google. Students can get solution of mathematical problems through internet. They can expand their knowledge through ICTs. They can get access to many lectures from all over the world.

My teacher participant T₃ expressed his view as

I always prepare myself to teach. I try to learn new pedagogy and problem solving methods. For this ICTs are very helpful for me. I always search on internet. I watch YouTube videos and study various article. I learned the way in which the concept of limit and continuity can be given to the students through GeoGebra with the help of YouTube (Interview transcription March 9, 2022).

Teachers prepare for the classroom by using ICTs. Teachers make an effort to learn new pedagogy and problem-solving techniques through ICTs. ICTs are extremely beneficial to teachers in this regard. Teachers do online searches. Teachers watch YouTube videos and read articles. So, ICT has created opportunities of self-learning for the teachers.

In this issue my first student participant S₃ expressed his view as

I always use internet to learn mathematics. For this firstly I decide what I have to learn then after I start to search on internet. For this I open various websites and watch various videos. I find many methods to solve then I select one or two of them then I copy that and practice that method (Interview transcription March 3, 2022).

Moreover my another student participant S₄ conveyed conveyed his opinion as

Sometimes our mathematics teacher takes us in ICTs classroom. In ICTs classroom teacher give us some questions then ask us to find the answers of those questions by using any application, website or videos. We find the answer and explain in the classroom. For example: Once our teacher gives us three questions. First, which geometric figure will be formed if a plane intersects a cone parallel to its base? (Interview

transcription April 4, 2022).

The mathematics teacher occasionally brings students to the ICTs classroom. Teachers in ICT classrooms provide questions to students and then ask them to search for the answers utilizing any program, website, or video. Students discover and discuss the solution in class. So, ICT has created opportunities of self-learning for students.

From the above interviews of the teacher participants and students I found both teachers and students are using ICTs as self-learning tool. Teachers are using it to find the learning pedagogies and to update themselves whereas students are using it to learn concept and problem solving methods. They are using it as self-learning tool in both inside and outside of the classroom. While using it inside the classroom teachers set the goal and students find the solution. It looks like discovery method. Self-learning enables individuals to learn what they want, when they want, and how they want (Karanja, 2017). ICTs have created an easy platform for self-learning.

Student Friendly Environment in Classroom

A pleasant classroom atmosphere is one in which students feel safe sharing their ideas, taking chances, asking questions, and tackling learning problems. Classroom environment is a synthesis of class's social, emotional, and educational components. According to research, several components of classroom environment can influence student motivation, and motivated students put more effort into learning activities (Ambrose et al., 2010).

In this issue my first teacher participant T₃ expressed his view as

When I use ICTs to teach mathematics in the classroom students become active. They take ICT tools themselves. They open the ICT tools and start to search what we have to learn. While we use ICTs

they learn in wider perspective. They digitally contact to each other. They complete their project within time. Actually ICTs decrease my role where it increases student's engagement (Interview transcription March 3, 2022).

My another teacher participant T₄ articulated his view as

Students used to complain with my teaching strategy. They used to say that my classroom is not collaborative. But now a days I take them to ICT lab to teach mathematics. They don't have any complain with my teaching strategy. Relation between us has been improved. So, I can say that Teaching mathematics through ICTs in the classroom create students friendly atmosphere (Interview transcription April 12, 2022).

Students become more engaged when teachers utilize ICTs to teach mathematics in the classroom. They bring their own ICT equipment. They open the ICT tools and begin to look for what they need to learn. Students learn in a broader context when teachers utilize ICTs. Students communicate online with one another. They finish their project in schedule. Actually, ICTs reduce teachers' roles while increasing student participation. So, use of ICTs is creating student friendly environment in the classroom.

When we interviewed on this issue my first student participant S₂ conveyed his view as

Learning mathematics through ICTs provide interesting, engaging and joyful environment for us. We learn the concepts and problem solving method in easy way. We always feel fresh and energetic in the classroom. Our focus toward learning increases (Interview transcription February 2, 2022).

My next student participant S₃ explained his experience as

It was very hard to complete the project work given by teacher in previous days. But after using ICTs in mathematics classroom it has been quite easy to complete. Our teacher give us project work to complete and he also give us chance to use internet in the classroom. We students use internet and try to find information related to our project work. We collaborate to each other. We also discuss on our curiosity related to our project work and try to find the best measure. It has enhanced our confidence level. We don't have any problem to present out work in front of the classroom with the help of ICTs (Interview transcription March 3, 2022).

From the interviews I came to know that teaching mathematics through ICTs can create student friendly environment in the classroom. It is helpful to create positive atmosphere in the classroom. It boosts the student confidence level and very helpful to fulfill the student's curiosity. Students enjoy the learning process and teacher duty is changed as mentor.

Akpan, Igwe, Mpamah and Okoro (2020) explain constructivist theory deemphasizes teacher-monotony in the classroom and encourages energetic interplay among learners, the instructor and other components of the educating learning process. I found ICTs are helpful to create student friendly learning environment. Both the instructor and the student agreed that an ICTS-friendly learning environment fosters more collaborative and supportive behavioral habits in the classroom (Mishra, 2020).

Opportunity of Teaching, Learning and Earning

Schools can do to improve learners' learning and earning potential (Mayer & Peterson, 1999). Teaching, learning, and earning at same time can motivate teacher to teach and student to learn. Many researches show that learning and earning have same importance in our life.

My first teacher participate T₆ explained her opinion as

I have a Facebook page namely GyanMaitri. I often upload the materials which I have taught in the class. I also upload the important questions for examination. There are 122 followers of my page. The maximum views I have got on a page is 799. I also have a YouTube channel GyanMaitri. I will upload videos related to mathematical content. After sufficient subscriber and followers I will monetize my both Facebook page and YouTube channel. This will provide me opportunity to learn (Interview transcription June 18, 2022).

My another teacher participant T₅ conveyed his view as

I am not earning through ICT integrated mathematics classroom but I know we can. One of my friends is earning from ICT integrated mathematics classroom. He has a YouTube channel and run live YouTube class. He has many subscribers and his channel is monetized. I don't know how much is he earning but I know he is earning through ICT integrated mathematics classroom (Interview transcription May 6, 2022).

Some teachers have their own Facebook page and YouTube channel. They often publish the things I have taught in class as well as important test questions. They monetize their Facebook page and YouTube channel once they get enough

subscribers and followers. This gives you the possibility to simultaneously learn and earn.

When I raised this issue in front of my student participant in interview. My first student participant S₃ conveyed his view as

Yes I know we can earn through ICTs by uploading our classes. It's not very hard. If we are allowed to take camera and laptop to school then we can easily capture our class and upload it in the YouTube channel. So I am agree with the statement that ICT integrated mathematics class can provide us the opportunities of learning and earning but we unfortunately we are not doing so (Interview transcription February 6, 2022).

My another student participant S₄ explained his opinion as

I am a bloggers and I upload the videos on my blogs. If I am given chance I can take video of the classroom. I can also make it live or upload is after editing. I have the skill of editing videos. I think if we have a channel related to mathematical content then we can easily get sufficient subscriber. After sufficient subscriber we can earn money (Interview transcription April 4, 2022).

My next student participant S₅ explained her view as

I always watch YouTube and pages to concept and problem solving. Then why we can't create our personal page and YouTube channel? This will give us the chance of learning and earning together. Our teacher who is one of the best teachers with experience of many years of teaching can easily give the concepts and problem solving tricks. If we upload or make it live then there will be a lots of viewers and there

*will be rain of subscribers. It will provide us opportunity to earn
(Interview transcription May 5, 2022).*

Some of the students are bloggers. They make videos with mathematical contents. For this, they learn mathematical content. They upload videos on their blogs. They can earn money by uploading mathematical content. ICT integration in teaching learning provide the opportunities of both learning and earning for both teachers and students.

From the interviews with teachers I came to know that teachers know that ICT integrated mathematics classroom can provide the opportunity to teach and earn together. Similarly from the interviews with students I came to know that they also know that there is an opportunity of learning and earning together with the help of ICT integrated mathematics classroom. Combining these two results I concluded that ICT integrated mathematics classroom can provide the opportunity of teaching, learning and earning together. Many researches of Nepal has showed that teachers have not sufficient salary in Nepal. Teaching through ICTs can provide the opportunity for the teachers to earn. From interviews I also conclude that every teacher and student know that ICT integrated mathematics classroom can provide opportunity to teaching, learning, and earning together but only few teachers and students are grabbing this opportunity. ICTs make teaching learning meaningful (Tsui, 2001).

Chapter Summary

ICTs integration in mathematics classroom has created a vast opportunities for teaching and learning. Motivation to learn mathematical concept, availability of finding learning materials, students' and teachers' interaction, opportunities of self-learning, fulfill the digital divide, and opportunity of teaching learning and earning are the opportunities created by ICTs integration in mathematics classroom.

Chapter VI

CHALLENGES OF ICTS INTEGRATION IN MATHEMATICS

CLASSROOMS

Challenges are obstacles or issues that rose from several areas at the same time and need significant work, patience, and resolve to deal with a collection of events (IGI Global, 2022). Third objective of my research was to investigate challenges of ICT integration in mathematics classroom. To fulfil that objective I used in-depth interview with teacher, head-teacher, student, and expert participants; classroom observation of my teacher participants; and focus group discussion with my student participants. I have explored various challenges of ICT integrated mathematics classroom. I have included the detail analysis of challenges of ICTs integration in mathematics classroom within this chapter. Insufficient infrastructures in school, lack of internet network, lack of willingness administration toward the ICTs' use, teachers insufficient knowledge of ICTs, lack of teacher's training of using ICTs, lack of time, insufficient budget for managing digital technology, lack of skilful manpower, digital divide, misuse of technologies, and high cost of ICTs' tools are themes that I have developed to describe the challenges of ICTs integration in mathematics classroom.

Insufficient Infrastructures in School

According to Vanderlinde and Braak (2010), ICTs' infrastructure assesses the perceived availability and usefulness of ICT tools such as hardware, software, and peripheral devices available in the school. According to Pelgrum's (2001), ICTs' infrastructure relates to the availability of equipment, software, Internet connectivity, and other related services. Computer lab, power supply, internet connection, multimedia projector, and display board are some essential ICTs' infrastructures for school. These infrastructures help to enhance ICT integrated mathematics classroom.

According to Cowie and Jones (2005), when ICTs' infrastructures are supplied in a good way, educators have more opportunities to use it.

My first teacher participant T₂ explained his view as

In our school there are two ICT labs with smart boards. There is facility of internet. There are 35 laptops and 35 tablets in ICT lab but only 25 seats for students. There are approximately 55 students in each of our classes. When we teach in that ICT lab, some students don't get seat to sit but they use laptops and tablets and do them self on laptop or tablet but that ICT lab is always packed. We have to get permission to take our students in that lab. There is always a queue to get turn for that lab. Another lab has a smart board and only 10 laptops. When we take out students to that lab each students cannot get laptop. While teaching in classroom we present our work in front of the students but students do not have opportunity to use our laptops. Similarly in class there is projector. I use that projector and demonstrate materials which I have already prepared. Students do not have opportunity to do themselves on ICT tools. Because of these causes I can say that my school has ICTs infrastructures but those are not sufficient and insufficient infrastructures are a barrier for ICTs integration in mathematics classroom (Interview transcribes February 6, 2022).

My another teacher participant T₃ shared his opinion as

In our school there is only one ICT lab. We have to wait in queue to get our turn to teach in that ICT lab. In ICT lab there is a smart board and only 15 laptops. Number of students in each class is 45. While I teach through ICTs in ICT lab each students can't get computer or

laptop. For classroom there are only three projectors. There is also a queue to get turn for projector. In some of the classes we can't use projector because of lack of arrangement of electric wires. If there were sufficient ICT tools in school then I had been using those frequently and number of ICT integrated mathematics classroom had been increased. So insufficient ICTs' infrastructure is barrier of ICTs integration in mathematics classroom (Interview transcription March 9, 2022).

My first student participant S₃ conveyed his view as

Sometimes our mathematics teacher takes us in ICT labs. He teaches us by using ICT tools and gives us to do our self on computer or laptop but in ICT lab we each student can't get laptop or computer so we have to share a single laptop among two or three friends. Once our teacher teaches us to find solve two equations of two variables by using excel. At that time, I clearly understand the process to solve and became excited to do myself on laptop. Unfortunately I had not laptop to solve. So, I only watched what my friends were doing. I felt very sad at that time (Interview transcription march 15, 2022).

My next student participant S₄ shared his view as

While teaching mathematics through ICTs. Our teacher comes with his own laptop in our class and ordered one of us to take projector from office room. Some of us go and bring projector in class. It takes about 10 to 15 minutes to manage projector in the class then teacher show PowerPoint and other materials which he has already prepared. We students don't have permission to even touch his laptop. If we all

students had laptop and we all has access to prepare and present mathematical concept and problem them it were more better then now (Interview transcription April 12, 2022).

From the interviews with teachers and students I came to know that there are insufficient ICTs' infrastructures in schools. All of the available infrastructures are not in working position. There is not sufficient number of laptops or computers in ICT lab. There is lack of tables, chairs, and other physical facilities in the ICT lab. Projector is not connected in each of the classes.

Most of the teachers and students clarified that in their school there is a lack of proper and sufficient infrastructure in their school. One of the student S₃ said “There is only one ICT lab in our school. This seems to be pack for all time (FGD transcription April 12, 2022).” When I observed ICT integrated mathematics classroom of my teacher participant T₅ in ICT lab I found that there were only one ICT lab in that school and only 32 computers among of them 9 were defective and the number of students were 42 (*Classroom observation May 15, 2022*).

From focus group discussion of my student participants and classroom observation I found same result as interviews with teachers and students. There was lack of sufficient ICT gadgets in school.

When I interviewed my expert participant E₁. He expressed his view as

I feel there is lack of proper infrastructures in schools. In school there are insufficient ICT friendly infrastructures. While I visited schools I found many schools don't have ICT friendly infrastructure. Some of the schools have insufficient ICT friendly infrastructure. There is lack of computer lab, power supply, internet connection, multimedia projector, and display boards. There is also problem of connectivity.

Many schools don't have internet connection, there is problem of power supply, and lack of software. While I observed schools I found available ICTs' infrastructures are teacher centred rather than student centred. Lack of ICT friendly infrastructure is barrier of ICTs' integration in mathematics classroom (Interview transcription December 10, 2022).

From the interview with expert I came to know that there is lack of ICT tools, and connectivity in schools. Some of the schools have developed ICTs' infrastructures but they are teacher centred. Teachers are not using ICTs in their class because of lack of infrastructures.

From the interviews with teachers, students, expert and classroom observation I concluded that lack of sufficient ICT friendly infrastructure is a crucial barrier for ICTs integration in mathematics classroom. I found three types of problem related to infrastructures. First is lack of ICT labs and ICT friendly classrooms. There is insufficient ICT gadgets, software and internet network in ICT lab and classroom. Second is all available ICT tools are not at working condition. Third is ICTs' related infrastructures are not student centred. All of these problems creating barriers for ICTs integration in mathematics classroom. ICTs integration in teaching and learning is hindered due to lack of infrastructure (Whitty, 2012).

Lack of Internet Network

Internet network is essential for ICT integrated mathematics classroom. If there is internet network in school teachers can get access to the new methods of teaching and can search new innovations and researches in mathematics. Similarly to use mathematical apps internet network is necessary.

Most of teachers emphasized that there is low level of internet network in

their school that causes low level of teaching. One of the teacher participants T₄ explained

I have to use mathematics related apps which needs high speed of internet network. In our school the internet network becomes always up and down while us use it in our class. When we take online class the similar problem occur. The pictures stopped and the fluency interrupted because of low internet network. Sometime the whole period (45 minutes) interrupted because of the internet network (Interview transcription April 12, 2022).

Another teacher participant T₅ expressed his view as

We use internet network to search various thing or content in mathematics. Internet is connected in our school but speed of internet is seemed to be very low. While we use internet network to search various thing related to mathematics it takes a long time. While we try to play videos related to mathematical concept it is interpreted. Poor internet network is barrier for ICT integration in mathematics classroom (Interview transcription May 20, 2022).

My next teacher participant T₆ conveyed her view as

There is internet network in our school but it is restricted to ICT lab and office. While we need to use it in the class we can't. In ICT lab while we want to use internet then it interpreted. No internet network and poor internet network is barrier of ICT integration in mathematics classroom (Interview transcription June 18, 2022).

One of the student participants S₂ expressed his view as

Sometime our sir start YouTube in ICT class but it stopped many times and we can't understand the concept. On online class our teacher's

video and sound stopped or cut for many time because of low internet network (Interview transcription June 18, 2022).

From the interviews with teachers and students I came to know that no internet network and low speed internet network is barrier of ICT integration in mathematics classroom. Schools have internet network but they are weak. Mathematics related apps high speed internet network. Some of the schools have restricted the internet network in the ICT lab. So teachers can't use it while they need it in the classroom. So I concluded that lack of internet network is a barrier of ICT integration in mathematics classroom. Teachers struggle to adopt and incorporate ICTs into teaching and learning for a variety of reasons, including poor infrastructure and internet connectivity (Bhatia & Ilyas, 2016).

Lack of Willingness Administration toward the ICTs' Use

Many researches show that positive administrative attitude helps to grow or implement plans in school. Many administrative persons seem to be positive toward ICT integrated mathematics classroom where as some were of negative.

One of my teacher participants T₃ conveyed his view as

Our headmaster is very cooperative in other thing but at the subject of ICT integrated mathematics classroom he is very bad attitude. He think in ICT room teachers sleep. It is right also at some extend because some of the teacher take students in ICT lab, play a long YouTube video and let them watch that video and teacher leave the class. But we never leave the class. We can give better concepts in ICT lab. Because of negative attitude of my head teacher I am no not using ICTs' in mathematics classroom (Interview transcription March 4, 2022).

One of student participant S₃ explained his view as

Our head sir always cry us if we want to go ICT lab. He said students have to study much more. Paper pencil is best way of learning. Students who are lazy and don't want to study always want to go ICT lab. They prefer entertainment rather than study (Interview transcription March 9, 2022).

Administrations appear to be resistant to ICT integration in the classroom. Negative attitude of headmasters toward ICT integration in classroom has reduced the frequency of use of ICTs in classroom.

Headteachers believes that children need to study more and that paper and pencil are the best tools to learn. The administration believes that ICT should be used for enjoyment rather than learning.

On this issue, one of the headmaster participants H₁ expressed his view as

Teachers who don't want to teach. ICTs' have been a better banana for lazy teachers. In ICTs' class teacher play a video and let the students to watch. It seems just time pass for teachers and students. Once I found teacher was students were watching a movie in mathematics classroom Teachers and students can't learn by ICTs. I think a mathematics teacher can teach better on whiteboard rather than in ICT lab (Interview transcription September 18, 2022).

Headteachers believe mathematics teachers can teach more effectively in traditional way rather than using ICTs. They consider that ICT are just for entertainment rather than teaching.

From the interviews with head teacher, teachers, and student I came to know that lack of willingness administration toward the ICTs' use is a barrier of ICTs

integration in mathematics classroom. I found head teachers don't have positive attitude toward ICT integrated classroom that's why teachers and students are restricted to use ICTs in mathematics classroom. School administrators' authoritarian management philosophies and their unfavourable perspectives on the use of ICTs in education are positively correlated (Ghamrawi, 2013).

Teachers Insufficient Knowledge of ICTs

Teacher's ICT knowledge and skill are very important for ICTs' integration mathematics classroom. To improve students' learning, teachers have to make use of their expertise (Walshaw, 2012). Many researches show that teachers' knowledge and students learning outcome are positively correlated.

My first teacher participant T₂ explained his view as

I use GeoGebra to teach mathematics in the classroom. I don't have any problem with my content but while using GeoGebra I use only two dimension graphs because I don't know how to use three dimensional space in GeoGebra. Once I taught conic section by using GeoGebra. At that time I use only two dimensional figures of cone and the plane. It became very hard for me to express three dimensional concept with two dimensional plane but if I were able to use three dimensional figures it had been more effective (Interview transcription March February 6, 2022).

My next teacher participant T₃ expressed his view as

I don't have problem with mathematics content but I don't know how to use ICTs in each of the chapters. I can use excel to teach statistics but I don't know how to teach trigonometric ratios by using ICTs. So I use MS-word to teach trigonometric ratios which is just like teaching on

white board. Sometime I show the picture of solved problem by using PowerPoint. I want to use python and GeoGebra to teach my students but I don't have skill to use those effectively. I don't have confident of teaching effectively through ICTs because of lack of skill of using ICTs. So that I accept that I have knowledge of content of mathematics and pedagogy but I don't have sufficient skill of using ICTs while teaching (Interview transcription March 9, 2022).

One of my first student participants S₃ conveyed his opinion as

I noticed that our teacher feel uneasy to run ICT tools. Sometimes he gets our help in GeoGebra. One thing I remembered is that one day our teacher was unable to open the GeoGebra saved file at that time one of our friend help him to open the file (Interview transcription March 3, 2022).

My another student participant S₄ expressed his view as

Our teacher wants to teach us through ICTs. He work hard for this this but I think he don't have sufficient skill because one day he tried to make a three dimensional figure of triangular prism but he can't. His objective was to draw a three dimensional figure of triangular prism and show us the animation. That day he opened GeoGebra and easily drew two dimensional figures of triangles and rectangles but while he tried to draw a three dimensional figure of triangular prism he faced a lot of problems and the time passed out without drawing a single three dimensional figure of triangular prism (Interview transcription April 4, 2022).

From the interview with teachers and students I came to know that both of the teachers and students are agree with one argument is that teachers has insufficient skill of using ICTs in mathematics teaching-learning. Teachers know that what are the applications can be used to teach mathematics but they don't have sufficient skill to use those apps. Lack of skill of running ICTs decreased the level of confidence of teachers. Which is also cause of limiting ICTs' integration in mathematics classroom? According to Balanskat et al. (2006), limitations in teachers' ICTs expertise cause them to be worried about utilizing ICTs in the classroom and consequently insecure about employing it.

In the focus Group discussion, my student participants S₅ argued as our teacher are very good in content knowledge and can explain and solve the problems on whiteboard quickly. But they have insufficient skill of ICTs. So they seldom use ICTs to teach us. Sometimes they feel confuse and ask us to help him. Sometimes he take long time to just display a simple thing. He uses only three applications one MS-word, MS-PowerPoint and GeoGebra. If he had sufficient knowledge he would have used other applications also (FGD, 23/6/2022). My student participant added that he is agree with this argument but his teacher also uses one more app excel (FGD transcription March 9, 2022).

From focus group discussion with students I came to know that students also feel that their teachers want to use ICTs a lot but they are not doing so because of lack of ICTs' skill. Their teachers are restrICTsed to only some apps like MS-word, MS-PowerPoint, MS-excel and GeoGebra because they don't know how to use other apps. According to Becta (2004), suggests that lack of teacher awareness of ICTs is a key obstacle to teacher acceptance of ICTs in the classroom.

Combing the results of interviews with student participants and teachers and the

FGD, I concluded that lack of knowledge of ICTs skills of teacher is decreasing the confidence level of teacher ICTs integration in classroom. Mishra and Kohler (2006) claimed that development of Technological pedagogical content knowledge (TPACK) is crucial for effective technology instruction. Our teachers have both pedagogical and content knowledge but they lack of technological knowledge. Pelgrum (2001) discovered that teachers' lack of knowledge and abilities is a significant barrier to implementing ICTs in secondary schools.

Lack of Teacher's Training of Using ICTs

MC (2021) claimed that training is essential for good teaching because it aids in the development of instructional plans. It up-to-dates teachers on the latest technology and equipment that may be used for teaching and learning activities. It helps to plan and prepare instructional aids and tactics. Many researchers found that lack of appropriate teacher training is a barrier to improve the ICT integrated mathematics classroom.

One of my teacher participants T₁ conveyed his opinion as

I have taken two training of ICTs but I felt they teach us vast concept rather than simple. We don't understand the concept they teach us. We want the training from beginning (Interview transcription March 9, 2022).

My another teacher participant T₂ expressed his view as

Teacher's trainings are helpful for us but duration and quality of those training are questionable. In the training of two or three days our trainer tries to provide us a lot of knowledge and skills. The training seems to be just formality. In teacher training trainers try to show their own capacity rather than enhancing our capability of ICTs' skills

(Interview transcription March 9, 2022).

Next teacher participant T₄ explained his view as

I was very excited for a teacher training of GeoGebra. It was my first training. For that training of ICTs. I paid Rs. 3000. At that training, after introduction session our first trainer starts a high level of programming in GeoGebra but I was not even able to download and run GeoGebra. At that time firstly I thought I can't use GeoGebra but when I return home I watched some videos of GeoGebra for beginners. I download and run GeoGebra for first time and make some two dimensional figures. In next GeoGebra training same event happened. Our trainer came and start from high level of concept. We are at the beginning stage then how we can understand the high level of concept so it is necessary to provide us the information's and skills from beginning (Interview transcription March 9, 2022).

From the interviews with teachers I came to know that Most of the teacher wants to use ICTs in mathematics classroom but they don't have appropriate training. Some of the teachers have taken training but still lack of confidence in using ICTs in mathematics classroom. I found there are three types of obstacles related to ICT integrated teacher training. First is insufficient number of teacher training second is the duration of training is not sufficient and third is content management in teacher training. Only few numbers of teachers training are conducted. Low quantity and quality of teachers' training is a barrier if ICT integration in mathematics classroom. Pelgrum's (2001) study was that there were not enough training opportunities for teachers in the use of ICTs in a classroom environment. The training seems to be of two to five days. Among of those days at least two sessions are spent on introduction

other thing and remaining time is insufficient for core training. Becta (2004) argued that time of training is also a component of effectiveness of training. Content of teacher trainings are not arranged from simple to complex. These three problems are decreasing the effectiveness of training which is barrier of ICTs integration in teaching learning.

Insufficient Time Period

Time is most important factor for teaching learning. A teacher have to finish their class in a certain (mostly forty five minutes) and syllabus in certain period of time (within one year).

One of my teacher participants T₂ argued as

While teaching mathematics through ICTs it takes quite more time than teaching on whiteboard. I taught trigonometric ratios of compound angles by using ICTs. For this I used MS-word. It took about two weeks to finish this chapter. If I were taught it by the traditional method then I would have been finished it in three days. So that I don't use ICTs frequently in mathematics classroom (Interview transcription February 6, 2022).

My next teacher participant T₃ explained his view as

I think our course is not designed for teaching through ICTs. While I teach through ICTs it took more time than traditional method. If I use only ICTs then I will not be able to finish my course on time. I take about 1.5 years to finish mathematics contents. So I use ICTs sometime to give the concepts and make students happy but not frequently (Interview transcription March 9, 2022).

One of my student participants S₃ shared his opinion as

Teaching-learning through ICTs is time taking. Our course was quite fast than other sections. Our teacher started to teach us through ICTs. He worked hard. He taught us trigonometry through ICTs. He used MS-word to teach compound angle, multiple angle, submultiple angle, and conditional trigonometric identities. He used to type on MS-word it used to take long time. We spent about two months on those chapters. He taught height and distance through GeoGebra it also took about 2 weeks to finish this chapter. Our chapters became delay and our teacher start to teach on whiteboard. He taught fast but we can't finished all the chapters fixed for second terminal examination (Interview transcription March 3, 2022).

From the interviews with my teacher participants and students I came to know that time management is a crucial problem for teaching mathematics through ICTs. I found two types of problem related to time. First is problem to finish the course in time and second is teaching mathematics through ICTs takes more time than traditional teaching methods. So teachers are not using ICTs frequently and insufficient time period has been a barrier for ICT integration in mathematics classroom. According to Becta (2004) research, a shortage of time impacts teachers' capacity to finish tasks in many elements of their profession, with some of the participating instructors particularly noting which aspects of ICTs demand more time.

Insufficient Budget for Managing Digital Technology

School budget plays vital role to develop infrastructure buy digital tools, and repair ICT tools on time. Many researches showed that schools with high budget can develop and manage the tools and man powers effectively.

One of my teacher participants T₅ expressed his view as

There is vast scarcity of ICT labs in our school but our administration doesn't pay attention toward it. In ICT lab there are many things to repair. In our school there is demand of a staff who can handle ICT lab. There may be scarcity of money budget in our school (Interview transcription May 15, 2022).

My another teacher participant T₁ expressed his opinion as

In our school there is only one ICT lab. In ICT lab there are some old generation computers and a smart board. There is need of new generation computers but there is lack of budget in our school. When we need to repair some ICT tools we always face economic problems. We don't have projector in the classroom because of low budget of our school. We always feel to have a technical person who can support us and manage ICT lab but it seems quite impossible because of low budgeting (Interview transcription January 3, 2022).

My first student participant S₆ explained his opinion as

In our school there is an ICT lab but computers are outdated. Most of the mouse doesn't work. When we open the computer it takes about 15 minutes. When we got some problem we can't find any person who can solve our ICTs related person. When we talk to our principal he always say that there is lack of budget (Interview transcription June 6, 2022).

From the interview with teachers and students I came to know that many schools have not sufficient budget to manage the ICT labs and tools. They don't have sufficient budget to buy or repair the ICT gadgets. These problems decrease the rate

of ICTs' integration in mathematics classroom.

My head teacher participant H₁ expressed his view as

Yes I know we need more ICT labs in our school and we need a person who can help teachers and take care of ICT lab. We also need to repair ICT tools but we don't have sufficient budget. There are many personal teachers of the school we have to pay them from the source of school and government have forbidden us to take fee from the students so it is very hard to manage. So there is always a problem of finance in school (Interview transcription January 1, 2022).

From the interview with my head teacher participant I came to know that schools are investing low on the ICTs because of low budget. Since the governments' schools don't have right to take fees with students they always have financial problems and they can't invest sufficient on ICT labs and tools. In short schools have problems of infrastructure related to ICTs because of low budget.

School financing is a critical issue that has direct implications to student accomplishment levels. Schools with lesser finances, which are often unable to provide small classrooms and better programming, have poorer student accomplishment, resulting in a financial divide in education (*American University, 2020*). Schools low financial capability is hindrance for the ICT integrated mathematics classroom.

Lack of Skilful Manpower

A skilled workforce handles everyday activities to accomplish and align organizational objectives. Productivity is improved. They use the existing technology as well as bringing new ones (Sefidari, 2017).

One of my teacher participants T₁ conveyed his view as

I want to teach mathematics with by using ICTs daily. I want to digitalize my class. But I don't know how to use ICTs in each chapters of mathematics. I am using ICTs in mathematics teaching but not regularly. I use ICTs in those chapters in which I know how to use ICTs. I know content and how to teach but I don't know how to teach by using ICTs. I accept that I am not a skilful manpower of ICTs that's why I am not using it frequently to teach mathematics (Interview transcription January 3, 2022).

My another teacher participant T₂ expressed his opinion as

I felt difficulties while teaching mathematics through ICTs for many times. If there were some one who can help me immediately then I would have also used ICTs frequently. I fell there must be a skilful manpower in school who can guide to use ICT tools and help us immediately when we need. If so done I will use ICTs frequently to teach mathematics (Interview transcription February 6, 2022).

My next teacher participant T₅ expressed his experience as

Once I were teaching to solve two equations through excel but at that time some functions of excel were not working. I felt very guilty at that time. If there were some one who can help me then I wouldn't have to be guilty. Some time I can't join the wires and give the electricity supply to the computers it take much more time at that time we feel the need of the skilful manpower in our school (Interview transcription May 15, 2022).

My next teacher participant T₄ expressed his view as

While teaching online I encountered various problems. At that time I felt I have lack of skills to run and manage ICT gadgets. I felt scarcity of a skilful person who could help me and solve my ICT related problems immediately (Interview transcription April 12, 2022).

One of my student participants S₂ shared his experience as

One day our teacher wants to run the projector but that day projector was not being on. Our teacher tried a lot and also said us to on the projector but we can't. That day we can't study because of the problem of projector. Next day our teacher explained that there were problem in setting in computer. If there were a skilful manpower in our school then obviously he/she had helped us to on and run the projector (Interview transcription February 2, 2022).

My another student participant S₃ conveyed his view as

While learning mathematics through ICTs we always encounter skill based problems. At that time we ask to teachers. Our teachers help us to solve the problem but some of the problems can't be solve by them. Our mathematics teacher is very good in mathematics but he also has some skill based problems which always can be felt at ICT classroom. At that time we (teacher and student) together want a skilful person who can help me but there is no one like this in our school (Interview transcription March 3, 2022).

From the interview with my teacher participants and students I came to know that there is scarcity of skilful manpower in schools. Teachers who want to teach mathematics through ICTs are not very skilful in ICTs. Mishra and Kohler (2006),

claimed that Technological pedagogical content knowledge (TPACK) is essential for integrating ICTs in teaching learning but our teachers are not sufficiently skilled in ICTs. There is scarcity of skilful manpower of ICTs who can solve the problems of teachers and students related to ICTs. Lack of skilful manpower is a hindrance of ICT integrated of mathematics classroom. Pelgrum (2001) stated that lack of knowledge and skill is nonmaterial barrier of ICT integration in classroom.

Digital Divide

Digital divide is defined as the gap between the people who have access and not to ICTs. According to Hanna (2021), digital divide refers to the disparity between populations and areas that have access to contemporary information and communications technology (ICT) and those who do not or have limited access. Telephones, televisions, personal computers, and internet access are examples of this technology.

My first teacher participant T₃ described his view as

In my class there are two types of students. First who have laptop, mobiles, and access to internet and other are who do not even a mobile phone. While I teach through ICTs both types of students become very happy and curious but when I give them the taught lessons as homework to do using ICTs some do and some answers like that they don't have ICT tools (Interview transcription March 9, 2022).

My another teacher participant T₄ explained his opinion as

Students who have digital devices at their home become very active during the class when I teach through ICTs and students who don't have digital devices at home are not active. One other thing I noted that while teaching problem solving exercises students having digital

devices and internet network came with the solutions of complex problem and those students who don't have digital tools at home depend only book and can't solve those problems (Interview transcription April 12, 2022).

My first student participant S₃ shared his view as

I have laptop and internet access at home. I always use these to find the solution of complex problems. I also share those to my other friends who have ICTs in their home. But I know some of our friends don't have proper ICT tools. They can't study like us. So digital divide is a barrier of ICT integration in teaching learning (Interview transcription March 3, 2022).

My another student participant S₄ shared his view as

Our teacher teaches us using ICTs. Some time he teaches in the classroom by using projectors but sometimes he take us to the ICT lab. When he teaches in the classroom using projector at that time he teaches and we have to do on copy. But when he takes us to the ICT lab we have to do on the ICT tools like laptop and tablet. At that time some of our friends who have access to ICTs at their home can do easily and fast but the students who have not access to ICT tools at home like us feel guilty and can't do easily. Teacher also gives us home works to do at home and submit via Gmail but I don't have access to ICTs so I always be unable to do like that (Interview transcription April 4, 2022).

From the interview with teachers and students I came to know that there is digital divide with in students. Digital divide is a vital problem for ICT integrated mathematics classroom. Students' academic achievements suffer as a result of the

digital divide in schooling (*Understanding the Digital Divide in Education*, 2020).

Misuse of Technologies

Misuse of technologies can create various problems. Misuse of technology can lead a person to the dark future. Technology has many benefits but misuse of technology has a lot of disadvantage.

One of my participant teachers T₃ expressed his experience as

Most of the students use ICTs as learning tool where as some students misuse it. In my class one day I checked what are the students doing? I found most of the students were doing exercises and using apps of mathematics and some of them were playing nonsense game. While I found that I decided not to use ICTs in classroom for a week (Interview transcription March 9, 2022).

My another teacher participant T₄ conveyed his view as

Sometimes I give homework to search some mathematical knowledge online. Some students make it the opportunity to play games and do other things which are not related to mathematics learning (Interview transcription April 12, 2022).

My next teacher participant T₅ argued as

Most of the parents complain that their children don't study at home they always spend time on mobile and laptops by playing games and watching fatal videos. Students take their mobile phone by saying that they will study by using it but they don't study. They play movies, games, and videos which are not related to their content. Sometimes they spent a lot of time by talking to their friends. They misuse technologies (Interview transcription May 15, 2022).

One of my student participant S₃ expressed his view as

Firstly I open the laptop to study but we can't control myself and start to play games. While playing games and watching videos I don't give attention toward the time and it became very late. Some time when my parents are not at home I started to watch my mobile soon after reach home from school and it became very late night when I stop. Once my daddy complaints to the teachers that I watch mobile a lot. After that my teachers stop giving homework on ICTs (Interview transcription March 3, 2022).

My another student participant S₅ conveyed her view as

I pay attention in the ICT integrated mathematics classroom but many of our friends don't. Some of our friends become busy on Facebook, Chat, and games which are not related to our content. One day of her friend send her a very ridiculous video in class while our teacher had given us classwork to do on laptop. For that I complained to the teacher. Teacher took action but it disturbed me for long time. I think ICT is a good tool for learning but it has been easy way to disturb someone (Interview transcription April 4, 2022).

My another student participant S₅ conveyed his view as

While our teacher use projector in our class at that time we pay attention toward learning. We don't get chance to misuse the technology. But when our teacher takes us to ICT lab we each get chance to play on laptop. At that time some of our friends misuse it. But I think if our teachers give us clear instruction this problem will be solved (Interview transcription May 5, 2022).

From the interview with teacher participants and students I came to know that some of the students misuse the ICT tools in classroom and at home. In ICT lab when teachers teach and give classwork some of the students play games, chat with friends and watch the videos which are not related to content. Some of the students disturb other by sending them unnecessary messages. So misuse of technology is a hindrance of ICT integrated mathematics classroom.

My participant headmaster H₁ expressed his opinion as

In school teachers always spend time on Facebook and YouTube rather than on student. Teachers misuse the internet network. The internet is not for that (Interview transcription September 10, 2022).

From the interview with head teacher I came to know that teachers also misuse the ICTs. They spent time on social media and watch unnecessary videos.

From the interviews with teachers, students, and administrative persons I concluded that both of the teachers and students misuse the ICTs. Students misuse it in the class and teachers misuse it in the school out of the class. Misuse of technology is a problem of ICT integrated mathematics classroom. The Misuse of Technology in the Modern Classroom and a Guide for Solutions (Fox, 2018).

High Cost of ICTs' Tools

Many researches shows that cost determine the utility of anything. Cost of any tool and utility of that tool are negatively correlated. Most of the ICT related equipments are of high cost. For example cost of laptop is more than Rs. 70,000. Similarly android mobiles costs high. The internet service is also expensive in Nepal. High cost of ICT equipments is a hindrance for the ICT integrated classrooms.

One of my teacher participants T₂ conveyed his opinion as

Cost of laptop is about triple of my monthly salary then how can I buy

laptop. So that I use only my android mobile to prepare myself for teaching using ICTs. The equipment I have to use in school is laptop and I prepare on mobile it also create a problem. If I were given a laptop or the cost of laptop were in my budget then I will be able to prepare more smartly then now (Interview transcription February 6, 2022).

My another teacher participant T₃ conveyed his view as

ICT tools are very expensive in Nepal. Our salary is very low. I am using the laptop which my brother has gifted from the foreign country. If my brother hadn't sent the laptop then I wouldn't able to buy because of low income. So, Government should decrees the taxes on laptops or give the subsidy on the laptops and mobiles for teachers and students to promote ICT integrated mathematics classroom (Interview transcription March 9, 2022).

One of the student participant S₂ shared his view as

I am from poor family there is only one mobile in my home which my father take with him while going outside to work. Our teacher run online class and I always miss that class. If the cost of the ICT tools were low then I my father would have bought laptop for me as other. So high cost of ICTS tools is also a hindrance for me to study (Interview transcription March 9, 2022).

My another student participant S₄ shared her view as

There is only one laptop in my home. Our parents can't buy another because of cost of the laptop. So I have to share the laptop with my elder brother. He is studying in BBM third semester. Most of the time

*he use the laptop and I don't get to practice my homework on laptop
(Interview transcription April 4, 2022).*

From the interviews with teachers and students I came to know that high cost of ICT tools are also a vital problem for ICT integrated mathematics classroom. Many of the teachers are unable to buy the proper ICT tools to teach. They are using their cell phone to prepare for teaching. There is scarcity of proper ICT tools for students. So that students can't practice at home what they learned at school.

My head teacher participant H₂ shared his view as

I have relished that we need more laptops, projectors, smart boards and other ICT tools but our budget is low and the cost of ICT tools are very high so we can't buy sufficient ICT tools. If it was of low cost then obviously we had bought the equipment and our teachers would not have any place to complain. My school would has been ICT friendly school (Interview transcription October 20, 2022).

From the interview with head teacher I came to know that schools can't fulfil the demand ICT tools because of high cost of ICT tools. The cost of ICT tools are high and the financial status of schools are low. The gap between the cost of ICT tools and financial status of school is hindrance of ICT integrated mathematics classroom.

From the interviews with teachers, students, and head teacher I concluded that high cost of ICT tools is a barrier for ICT integrated classroom. Teachers can't buy the highly priced laptops and other tools that's why they can't prepare properly. Students can't but the equipment and can't practice at home. Because of high cost of ICT tools schools can't buy sufficient ICT gadgets which decreases both quantity and quality of ICT integrated mathematics classroom.

Chapter Summary

Insufficient infrastructures in school, lack of internet network, lack of willingness administration toward the ICTs' use, teachers insufficient knowledge of ICTs, lack of teacher's training of using ICTs, lack of time, insufficient budget for managing digital technology, lack of skilful manpower, digital divide, misuse of technologies, and high cost of ICTs' tools are the barriers of ICTs integration in mathematics classroom. According to Snoeyink and Ertmer (2002), widespread barriers include a lack of computers, a lack of quality software, a lack of time, technical problems, teacher attitudes toward computers, a lack of funding, a lack of teacher confidence, resistance to change, a lack of administrative support, a lack of computer skill, a lack of fit with the curriculum, scheduling difficulties, a lack of training opportunities, and a lack of vision for integration.

Chapter VII

COPING STRATEGIES OF CHALLENGES

In previous chapter VI, I have discussed on challenges of ICT integrated mathematics classroom. My fourth research question was "How do teachers address the challenges of ICTs integration in mathematics classroom?" In this chapter I have discussed on the coping strategies of the challenges of ICTs integration in mathematics classroom. To fulfil that objective I used in-depth interview with teacher, student, head-teacher, and expert participants and focus group discussion with student participants. In this chapter, I have included detail analysis of coping strategies of challenges of ICT integrated mathematics classroom. I have developed some themes to describe the coping strategies. Developing ICT friendly infrastructures, conducting effective teacher training for ICT integrated mathematics teaching learning, developing a well acceptable app, redesigning the syllabus, minimizing the cost of cost tools, and recruiting the skilful manpower are the themes under which I have described the coping strategies.

Developing ICT Friendly Infrastructures

According to Vanderlinde and Braak (2010), ICT infrastructure evaluates the perceived availability and usefulness of ICT tools such as hardware, software, and peripheral devices available in the school. Infrastructures are helpful for teaching and learning in a classroom. Proper infrastructure can provide better environment for teaching learning.

One of my teacher participants T₂ shared his view as

Infrastructure is essential for ICT integrated mathematics classroom.

Schools must have ICT friendly infrastructure to promote ICTs'

integration in mathematics classroom. There must sufficient ICT

gadgets for the students so that they can practice what he/she learned (Interview transcription February 1, 2022).

My another teacher participant T₃ shared his view as

Proper infrastructures provide students to sit easily and learn more. Sufficient number of laptops, projectors, table, chairs and management makes teaching easy. Better soft wares and internet connections can provide better access to the students and teachers. These all means there must be proper infrastructure in the school (Interview transcription March 5, 2022).

My another teacher participant T₄ shared his view as

In each class there must be one projector and the trunk where students can put their laptops and other gadgets. There must be fast internet access and availability of soft wares which we need. We don't have access to internet in classes. There must be access to internet in each class (Interview transcription April 8, 2022).

One of my student participants S₃ shared his view as

Our school needs to develop ICT friendly infrastructures. There must be sufficient tables and chairs for us in ICT lab. There must be sufficient number of laptops and other ICT gadgets for us (FGD transcription March 9, 2022).

From the interviews with teachers and students I came to know that proper infrastructure is one of the solutions of the problem of ICT integrated mathematics classroom. Internet access to all classes, availability of laptops and other ICT gadgets, proper soft wares, and other ICT related infrastructure is needed in each school. Proper number of tables and chairs are also be made in each schools.

My expert participant E₁ expressed his view as

Proper ICT friendly infrastructure is helpful in teaching and learning mathematics through ICTs. In each school there must be sufficient number of ICT gadgets, tables, chairs, projectors, smart boards, light and air. Internet access and proper software are also necessary within the infrastructure. Developing student centred ICT infrastructures will be helpful for teaching-learning (Interview transcription December 10, 2022).

From the interview with expert I came to know that developing student centred ICT infrastructure is essential for quality-teaching learning through ICTs. From the interviews with teachers, students, and exports I concluded that to encounter the issue of infrastructure student centred ICT friendly infrastructure should be developed in each school. According to Cowie and Jones (2005), the ICTs' infrastructure allowed instructors to access the school network, the Internet, and laptop attachments (printer, digital camera, data projector, large TV screen, scanner, and video camera). Having sufficient tables, chairs, laptops, computers, soft wares, internet connection, lighting system, fresh air pass system can increase the number of ICT integrated mathematics classes and its output. As a result, when ICTs' infrastructures are well-maintained, instructors have greater opportunities to use instructional technology (Jones, 2005).

Conducting Effective Teacher Training for ICTs' Integration in Mathematics Teaching-learning

From the interviews with teachers I came to know that most of the teacher wants to use ICTS in mathematics classroom but they don't have appropriate training. Some of the teachers have taken training but still lack of confidence in using ICTS in

mathematics classroom. I found there are three types of obstacles related to ICT integrated teacher training. First is insufficient number of teacher training second is the duration of training is not sufficient and third is content management in teacher training. Only few numbers of teachers training are conducted. Pelgrum's (2001) study was that there were not enough training opportunities for teachers in the use of ICTs in a classroom environment. The training seems to be of two to five days. Among of those days at least two sessions are spent on introduction other thing and remaining time is insufficient for core training. Becta (2004) argued that time of training is also a component of effectiveness of training. Content of teacher trainings are not arranged from simple to complex. These three problems are decreasing the effectiveness of training.

One of my teacher participants T₂ conveyed his view as

ICT related teacher training should be arranged from simple to complex. In teacher training I don't want to learn a lot but I want to learn those thing which I can apply in mathematics classroom. Our rosters teach us a lot. They teach us hard concepts. Which we can't understand or use in the classroom. So, I feel teacher training is not effective and we need effective teacher training to solve the problem and make it usable in teaching learning (Interview transcription February 5, 2022).

My another teacher participant T₃ shared his view as

Number of ICTS related teacher training and its duration should be increased to increase the effectiveness of the teacher training. If the duration of teacher training will be increased then teachers will get chance to practice more. Increments in number of training related to

ICTs will provide chance to a teacher to attain the training multiple times (Interview transcription March 9, 2022).

My next teacher participant T₄ shared his view as

Our head teacher and students also needs training of ICTs. Our head teacher needs training to make his attitude positive toward ICT integrated mathematics classroom. Our students need training to be aware of misusing it (Interview transcription April 12, 2022).

From the interviews with teachers, I came to know that effective teacher training can improve the quality of ICT integrated mathematics classroom. Teachers want to learn from beginning in the teacher training. They want to practice more in teacher training. They want the content from simple to complex. They want to increase number of training and duration of training. If these problems are solved in the training then the training will be effective. To develop positive attitude toward ICTs head teacher should be convinced by training.

My head teacher participant H₁ expressed his view as

My teachers attend the training but they don't use it in school. So training should be motivational so that teachers can apply what they learned in training. Teaches should be positively motivated for ICT integrated mathematics classroom in teachers training. Some of teachers use ICTs for two or three days after training but then start to teach by the traditional method. So in training they should be trained to use ICTs frequently. If these problems are addressed in the training then the training will be effective (Interview transcription June 6, 2022).

From the interview with head teacher I came to know that to increase

effectiveness of training it should be motivational. Teachers should be motivated to use ICT tools frequently.

My expert participant E₁ shared his view as

Teacher training related to ICTs are not seems to be effective. I think there must be a training of developing apps rather than using the previously developed apps. I think in teacher training there must be training of coding. Graphics must be added in teacher training (Interview transcription December 10, 2022).

From the interview with expert I came to know that for effective teacher training teachers should be taught coding. In training teachers should be trained to develop their own apps and software according to their needs.

From the interviews with teachers, head teacher, and expert I concluded that effective teacher training can enhance the quantity and quality of ICT integrated mathematics classroom. Mishra and Kohler (2006), claimed that development of technological pedagogical content knowledge (TPACK) in instructors is crucial for effective teaching-learning through ICTs. Our teachers have pedagogical and content knowledge but they need training to improve their technical knowledge. To make teacher training effective the content of training should be arranged from simple to complex, number and duration of training should be expand, and it should be motivational According to Becta (2004), the topic of training is surely difficult since numerous components must be considered to ensure the efficiency of the training. These were times for training, pedagogical training, skill development, and the use of ICTS in basic teacher training.. The next things which training should include are coding and graphics. In training teachers should be trained to develop their own apps and software according to their needs. Teacher training can be made effective by

addressing all these things. Effective teacher training will upgrade the quality of ICT integrated mathematics classroom.

Developing Well Acceptable Apps

Well acceptable apps mean the app which teacher all over the Nepal can use and be included in the syllabus of mathematics. Well acceptable app makes teaching learning uniform.

One of my teacher participants T₃ expressed his view as

While I talk to experts and other teachers about the good apps for teaching mathematics I find variety on their perception. Some emphasis on using GeoGebra, some on python and some recommend others. If government of Nepal make our own app and suggest us to use then there will be informality in apps. Teachers of all over the Nepal can use the same kind of apps and their efficacy will be increased day by day (Interview transcription March 9, 2022).

One of my student participants S₂ expressed his view as

I use multiple apps for mathematics learning. Sometimes I became confused which app is best. The methods of using apps are also different. So I want a well acceptable apps developed by government of Nepal in which I can practice more (Interview transcription February 5, 2022).

From the interviews with teachers and students I came to know that a well-accepted app can enhance the ICT integrated mathematics classroom. It will increase the uniformity in teaching learning. It will free teachers and students from perplexity of using many apps.

One of expert participant E₂ shared his view as

Developing a single app and using in the schools of Nepal to teach mathematics through ICTS is better idea. It will make easily to conduct training and we can develop the app as per our course of study. We can make it easy to run. If teachers use the same app daily their practice on that app will be high and using after some days teachers will feel easy to use that app. We experts will also be focused on the app and make is more effective and easy each year (Interview transcription November 20, 2022).

From the interview with expert I came to know that a well-accepted app can make teachers and students to use and experts to conduct training revise it each year as our syllabus.

From the interviews with teachers, students, and experts I conclude that well acceptable app can be solution of the hindrance of ICT integrated mathematics classroom. Specialized interactive app developed to help the development of early mathematics abilities and provided on hand-held tablets is successful at increasing mathematical achievement in students in both low- and high-income nations (Pitchford & Outhwaite, 2019). It will increase focus and practice of teachers and teachers will be able to use it frequently after one or two years. It will be developed as the demand of our course which will be effective in teaching-learning through ICTs.

Redesigning the Syllabus

Creating useful and measurable learning outcomes, selecting effective teaching strategies and learning experiences, aligning assessment methods with course learning outcomes, and revising the course syllabus are all part of course redesign (Fink, 2013). It means introducing burning issues and ICTs in syllabus.

One of my teacher participants T₄ conveyed his view as

Syllabus of mathematics is long. I hardly finish it on time. If I teach it through ICTS then I can't finish it on time. Syllabus must be redesign so that we can finish it on time even we teach through ICTs. Some ICTS related mathematics must be introduced in syllabus. In the pedagogical part ICTS must be included (Interview transcription April 12, 2022).

My another teacher participant T₅ expressed his opinion as

ICT friendly syllabus is needed to teach mathematics through ICTs. Syllabus must be shorter than now and in each chapter there must be instruction for teacher that how we can teach it through ICTs (Interview transcription May 15, 2022).

My next teacher participant T₆ explained her opinion as

Our evaluation system should be changed as the demand of society. We have to include ICTs in examination system. There must be sixty percent of written test and forty percent of practical. For practical students should be tested that either students can solve the problems through ICTs or not (Interview transcription June 18, 2022).

From the interviews with teachers I came to know that ICT friendly mathematics syllabus should be developed. Every teacher preparation course must incorporate aspects that encourage the development of ICT competences in both instructors and students, hence promoting the integration of ICTS in mathematics instruction and other educational programs (Ezeugwu et al., 2016). Government of Nepal should redesign the syllabus so that teachers can finish it on time even they teach through ICTs. In evaluation system mathematics through ICTs be introduced.

Minimizing the Cost of ICT Tools

Cost of ICT tools is a barrier for ICT integrated classroom. Teachers can't buy the highly priced laptops and other tools that's why they can't prepare properly.

Students can't buy the equipment and can't practice at home. Because of high cost of ICT tools schools can't buy sufficient ICT gadgets which decreases both quantity and quality of ICT integrated mathematics classroom.

One of my teacher participants T₂ expressed his view as

Cost of laptop is about triple of my monthly salary then how can I buy laptop. So that, I use my android mobile to prepare myself for teaching using ICTs. The equipment I have to use in school is laptop and I prepare on mobile it also create a problem. If I were given a laptop or the cost of laptop were in my budget then I will be able to prepare more smartly then now (Interview transcription February 6, 2022).

Moreover he added "Government should decrease the taxes on ICT tools or should be given subsidy to teachers, students, and schools on the ICT tools."

My another teacher participant T₄ conveyed his view as

If the cost of ICT tools are decreased than the problem of digital divide will be solved. Similarly our each teacher and student will have their own ICT tools. Similarly our schools will have sufficient number of laptop and other ICT tools which decreases the problems created by insufficient number of ICT tools (Interview transcription April 12, 2022).

Another teacher participant T₅ added

Government should pay attention toward the cost of internet in Nepal. It should be decreased. If the cost of internet is will be decreased then

every students, teachers, and schools will have internet access which will be helpful to increase the quantity and quality if ICT integrated mathematics classroom (Interview transcription May 15, 2022).

From the interviews with teachers I came to know that decreasing cost of ICT tools and internet is solution for the problems which is caused by insufficient number of ICT tools and connectivity. Despite significant cost reductions in ICT tools in recent years, most schools are still unable to afford them (Bajracharya, 2017). If the cost of ICT tools is decreased then it will decrease the digital divide. Each teachers and students will have their own ICTS gadgets which will help them to practice at any time. Similarly each school will have sufficient number of ICT tools which will be create ICT friendly environment in school. If the cost of internet will be decreased then each teachers and students will have access to internet. There will be availability of internet access in each class.

Recruiting Skilful Manpowers

There is scarcity of skilful manpower in schools. Teachers who want to teach mathematics through ICTs are not very skilful in ICTs. There is scarcity of skilful manpower of ICTs who can solve the problems of teachers and students related to ICTs. Lack of skilful manpower is a hindrance for ICT integrated of mathematics classroom.

One of my teacher participants T₃ conveyed his view as

At least one ICTS expert should be recruiting in each school. One of the responsibilities of the expert should be defined as to help those teachers who need his/her help. He/she should conduct regular training for those teachers who are weak in ICTs (Interview transcription March 9, 2022).

My another teacher participant T₄ expressed his view as

At least one ICTS expert should be recruit. Schools should confirm about his/her ICTS capability when recruiting other subject teachers. For example if school is going to recruit a mathematics teacher then it should select the teacher who can teach through ICTs (Interview transcription April 12, 2022).

From the interviews with teachers I came to know that to solve the problem of lack of skilful manpower of ICTs schools should recruit skilful manpower. The vast array of skills and experiences that skilled workers possess makes it easier for them to address problems and identify inconsistencies in organizational requirements (Chabbria, 2022). Two types of skilful main power should be recruited in school. First ICTS experts and second subject teachers who can teach through ICTs.

Chapter Summary

Insufficient infrastructures in school, lack of internet network, lack of willingness administration toward the ICTs' use, teachers insufficient knowledge of ICTs, lack of teacher's training of using ICTs, time, insufficient budget for managing digital technologies, lack of skilful manpower, digital divide, misuse of technologies, and high cost of ICTs' tools are challenges and barriers for developing ICT integrated mathematics classroom. Those challenges can be encountered by developing ICT friendly infrastructures in schools, conducting effective teacher training for ICT integrated mathematics teaching learning, developing a well acceptable app, redesigning the syllabus, minimizing the cost of ICT tools, and recruiting the skilful manpower.

Chapter VIII

FINDINGS, CONCLUSIONS AND IMPLICATIONS

This chapter includes the findings, conclusion, and implications of my study. I related the findings with objectives and research questions. I concluded my research regarding to the objectives as well as research questions. My research is applicable for teachers, students, policy developers and curriculum designers.

Findings

For findings of my research I have included my research objectives, their corresponding research question, used tools, and corresponding findings.

My first research objective was to explore the practice of ICTs in mathematics class room and the corresponding research question was how do teachers and students practice ICTs in mathematics classroom? I have developed chapter IV namely ICTs practice in mathematics classroom to fulfil the objective and find the answer of the question. Through the process of in-depth interview with teachers, students, experts and administrators, classroom observation of teachers, focus group discussion with students and informal interactions with teachers, students, exports and administrators, I have captured the way in which teachers are teaching mathematics using ICTs and the way in which students are learning mathematics through ICTs.

I found, teaching and learning mathematics through ICTs has increased after Covid-19. Most of the teachers use office programs like MS-word, Power-Point, MS-excel to teach mathematics. Some of the teachers use GeoGebra. ICTS seems to be just a demonstrating tool in most of the mathematics classes. But use of ICTs in mathematics classes makes students proactive. They seem to be active and curious while a teacher teaches mathematics through ICTs. Using ICT tools in mathematics classroom is itself being gamification of mathematics. Some of the teachers uses

quizzes of mathematics which makes mathematics fun. Use of ICTs in mathematics teaching learning increasing student's engagement and gradually digitalizing learning process. Regarding to my first objective I found teachers and students are practicing ICTs by students' engagement, demonstrating resources, gamification of mathematics, and mathematics learning through applications. In fact practice of ICTs in mathematics is gradually transferring from office programs to special mathematical applications.

My second research objective was "To explore the opportunities created by ICTs integration in mathematics classroom." The corresponding research question was "What are the opportunities created by ICTs integration in mathematics classroom?" To fulfill this objective and answer the research question I have developed chapter V namely opportunities of ICT integration in mathematics classroom. In-depth interview and focus group discussion were the tools which I used to fulfill this objective and answer the research question.

I found ICTs integration in mathematics classroom has created a vast opportunities for teaching-learning. Motivation to learn mathematical concept, availability of finding learning materials, students' and teachers' interaction, opportunities of self-learning, fulfill the digital divide, and opportunity of teaching learning and earning are the opportunities created by ICTs integration in mathematics classroom. In short, ICT integration in mathematics classroom has created huge opportunities which indicated the bright future of it.

My third objective of my research was "To investigate challenges of ICTs integration in mathematics classroom." The corresponding research question was "What are the challenges of ICTs integration in mathematics classroom?" To fulfill this objective and answer the research question I have developed chapter VI namely

challenges of ICTS integration in mathematics classroom. In-depth interview and focus group discussion were the tools which I used to fulfill this objective and answer the research question.

I found Insufficient infrastructures in school, lack of internet network, lack of willingness administration toward the ICTs' use, teachers insufficient knowledge of ICTs, lack of teacher's training of using ICTs, lack of time, insufficient budget for managing digital technology, lack of skilful manpower, digital divide, misuse of technologies, and high cost of ICTs' tools are challenges of ICTS integration in mathematics classroom. Although there are alots of oppertunities of ICT integration in classroom there are some barriers to integrate ICTs in mathematics classroom.

My fourth research question was "How the challenges of ICTs integration in mathematics classroom can be addressed?" To find answer the research question I have developed chapter VII namely coping strategies. In-depth interview and focus group discussion with my teacher, student, heard teacher, and expert participants were the tools which I used to answer the research question.

I found developing ICT friendly infrastructures in schools, conducting effective teacher training for ICT integrated mathematics teaching learning, developing a well acceptable app, redesigning the syllabus, minimizing the cost of ICT tools, and recruiting the skilful manpower are the coping strategies of the challenges of ICTs integration in mathematics classroom. There are some probles to integrate ICTs in mathematics classrrom but problems can be solved by applying copping strategies.

Conclusions

ICTs integration in mathematics classroom is at beginning stage. Teachers and students both are practicing ICTs in mathematics by their choice but they are facing a

lot of problems. Those problems should be reduced. Collective positive efforts of teachers, students, head teachers, experts, trainers, and policy makers are needed to reduce the problems.

Mathematics teachers are using ICTs by choice. They don't use ICTs daily. Most of the mathematics teachers use office programs likes MS-word, MS-excel, MS-PowerPoint and only mathematics app GeoGebra. During the period of covid-19 they used zoom, Google class, and teams.

ICTs integration in mathematics classroom has created vast opportunities for both teachers and students. It has opened the door of knowledge and provided an enormous platform for both teachers and students. It has motivated students to learn and created the opportunities of self-learning. It has increased the teachers' and students interaction.

ICTs integration in mathematics classroom has created many opportunities for both teachers and students but there are many challenges to integrate ICTs in mathematics classroom. Insufficient infrastructures in schools, teachers' insufficient knowledge of ICTs, lack of teachers training, lack of skilful manpower, and misuse of technologies are some of the challenges.

These challenges can be addressed by developing ICT friendly infrastructures in schools, conducting effective teacher training for ICT integrated mathematics teaching learning, developing a well acceptable app, redesigning the syllabus, minimizing the cost of ICT tools, and recruiting the skilful manpower.

The teaching learning pedagogies are gradually shifting to ICT integration. ICT integration in mathematics classroom has created a vast opportunities for both teachers and students but there are some challenge to integrate ICT in mathematics classroom. There are some coping strategies to address those challenges.

Implications

I have described the implications of my research into four parts. Implication for teachers, implication for students, implication for schools, and implication for policies are subtopics under which I have described implications of my research.

Implication for Teachers

I found, ICT integration in mathematics classroom creates vast opportunities. So, my study would be guideline for the teachers to create ICT friendly classroom environment. This would be also a parameter for instructors to know the expectations of the learners and to implement tactics that assist the learners as well as their involvement. It would make teachers aware of the need of motivating students, making ICTs integration in mathematics classrooms more dynamic and exciting, and implementing a collaborative learning atmosphere. Similarly, teachers should give rapid feedback and opportunities to enhance internal examination. It also advises instructors to consult with schools regarding student difficulties and identify acceptable solutions.

I also found that teachers are using MS-office programs to teach mathematics so it would be guideline for those teachers to increase the use of mathematical applications gradually. Teachers play a crucial role in curriculum implementation and accomplishing the objective of curriculum. Because he/she would be in charge of the teaching-learning processes, the teacher in ICTs integration in mathematics classroom should be efficient in both knowledge and competence. Integrating mathematical content with modern technologies is a difficult task. As a result, before beginning an ICT integrated class, the instructor should be well-prepared in terms of knowledge and competence. My research would assist instructors in properly using digital pedagogy in mathematics. This study would be beneficial for instructors to be

taught as needed to utilize mathematical software and to comprehend the concerns and limitations of digital learners.

As a result, the teacher has several duties and problems in order to achieve the educational aim and meet the needs of the students. As a result, the school should recognize the instructors and take their facilities and issues seriously.

In short, I recommend teachers to integrate ICTs in mathematics class-room. I also recommend those teachers who are using ICTs in mathematics classroom to maximize the use of ICTs with applications related to mathematics.

Implication for Students

This study would be a guideline for the students to manage all of the technological equipment required in digital learning, as well as be familiar with mathematical software and gadgets to utilize in numerical issues. In this sense, my research would be valuable to students and teachers as well as schools and authorities.

Learners are at the core of the teaching-learning process. The nation, students' parents and schools have made significant investments in education. If the students are not committed and accountable, the investment is a waste of time. This research would help learners become acquainted with the digital learning process and its obstacles. They prepare themselves mentally and externally before beginning interactive learning if they get familiar with the problems. I anticipate that my research will assist learners in becoming acquainted with the digital learning approach in mathematics and in learning about the problems that the learners have encountered. Similarly, it would encourage learners to psychologically prepare before beginning interactive learning and to have fundamental ICTs' skills in order to finish interactive learning.

Implication for Schools

I anticipate that it will serve as a guideline for schools, NOU, TU and other institutions in reducing the administrative, teacher, and authority issues associated with ICT integration in mathematics classroom. It would assist universities in developing practical and practice-based mathematics curriculum. In addition, this project will raise awareness among universities and schools to give in expensive data packs or other alternative resources to students in collaboration with Nepal Telecom or solar/inverter firms. I anticipate that it will recommend fostering flexibility in the learning environment as needed, as well as an analysis and assessment of the existing situation. Similarly, this study would offer institutions with criteria for providing adequate training to staff members and students.

It would be a valuable document for schools to adopt engagement strategies and include relevant stakeholders so that people feel involved in system implementation. This report, in my opinion, would be a watershed moment in identifying existing good practices in education and consulting with other schools to obtain digital experiences as well as raising digital learning standards by focusing on user experiences, meeting the needs of learners, and maintaining student satisfaction. It would imply that the institutions appreciate the teachers and take their facilities and difficulties seriously.

Policy Implications

This study would be useful at the policy level in developing long-term and short-term visions for achieving the purpose of education in a different way. Similarly, involving all stakeholders in developing a plan for the adoption of digital learning in schools would be beneficial.

It also aids in the development of technology and the use of technical skills in

the field of education, as well as the monitoring and evaluation of the digital teaching-learning efficacy. My research would alert policymakers to the problem of Insufficient infrastructures in school, lack of internet network, lack of willingness administration toward the ICTs' use, teachers insufficient knowledge of ICTs, lack of teacher's training of using ICTs, lack of time, insufficient budget for managing digital technology, lack of skilful manpower, digital divide, misuse of technologies, and high cost of ICTs' tools are challenges of ICT integration in mathematics classroom. My research will also encourage them to minimize the barriers by involving the pans of developing ICT friendly infrastructures in schools, conducting effective teacher training for ICT integrated mathematics teaching learning, developing a well acceptable app, redesigning the syllabus, minimizing the cost of ICT tools, and recruiting the skilful manpower in upcoming policies.

Curriculum Implication

This study would be helpful for currulumum level in developing ICT friendly mathematics currucumum. This would be a guideline for developing ICT integrated mathematics contents. It would be helpful in guiding the teachers to teach mathematics using ICTs. It would be supportive for curriculum level to integrate ICTs in evaluation system of mathamatics.

Since I found that teachers want to teach through ICTs and students want to learn through ICTs so that my research would be guide line for the curriculum developers to develop ICT integrated mathematics syllabus. So that teachers can teach by using ICTs, students can learn through ICT and evaluation system should be ICT integrated rather than traditional paper paencil test.

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Appendix-I

Interview guideline for teacher participants

Respected sir/madam, Me Ranadhir Kumar Sah. I am here with Degree of Master of Philosophy in Mathematics Education research work. This will be focused on the practices of ICTs' in mathematics classroom. I will take many key notes during this interview. I will also captured you voices in my mobile. I want to ensure you that this information will be used only for academic purpose.

1. How do you think about ICTs' integration in mathematics classroom?

.....
.....

2. How are you integrating ICTs in mathematics classroom?

.....
.....

3. How ICTs integration in mathematics classroom helping you in teaching?

.....
.....

4. What are the problems of ICTs integration in mathematics classroom?

.....
.....

5. How those problems can be solved?

.....
.....

Thank you

Appendix-II

Interview guideline for student participants

Dear students, Me Ranadhir Kumar Sah. I am here with Degree of Master of Philosophy in Mathematics Education research work. This will be focused on the practices of ICTs' in mathematics classroom. I will take many key notes during this interview and record your voice in my mobile. I want to ensure you that this information will be used only for academic purpose.

1. How do you think about ICTs' integration in mathematics classroom?

.....
.....

2. How is your teacher integrating ICTs in mathematics classroom?

.....
.....

3. How ICTs integration in mathematics classroom helping you in learning?

.....
.....

4. What are the problems of ICTs integration in mathematics classroom?

.....
.....

5. How those problems can be solved?

.....
.....

Thank you

Appendix-III

Focus group discussion guideline for student participants

Dear students, Me Ranadhir Kumar Sah. I am here with Degree of Master of Philosophy in Mathematics Education research work. This will be focused on the practices of ICTs' in mathematics classroom. I will take many key notes during this interview and record your voice in my mobile. I want to ensure you that this information will be used only for academic purpose.

1. How do you think about ICTs' integration in mathematics classroom?

.....

2. How are you integrating ICTs in mathematics classroom?

.....

3. How ICTs integration in mathematics classroom helping you in teaching?

.....

4. What are the problems of ICTs integration in mathematics classroom?

.....

5. How those problems can be solved?

.....

Thank You

Appendix-IV

Interview guideline for head teacher participants

Respected sir/madam, Me Ranadhir Kumar Sah. I am here with Degree of Master of Philosophy in Mathematics Education research work. This will be focused on the practices of ICTs' in mathematics classroom. I will take many key notes during this interview. I will also captured you voices in my mobile. I want to ensure you that this information will be used only for academic purpose.

1. How do you think about ICTs' integration in mathematics classroom?

.....
.....

2. How are your mathematics teachers integrating ICTs in mathematics classroom?

.....
.....

3. How ICTs integration in mathematics classroom helping you in teaching?

.....
.....

4. What are the problems of ICTs integration in mathematics classroom?

.....
.....

5. How those problems can be solved?

.....
.....

Thank you

Appendix-V

Interview guideline for expert participants

Respected sir/madam, Me Ranadhir Kumar Sah. I am here with Degree of Master of Philosophy in Mathematics Education research work. This will be focused on the practices of ICTs' in mathematics classroom. I will take many key notes during this interview. I will also captured you voices in my mobile. I want to ensure that this information will be used only for academic purpose.

1. How do you think about ICTs' integration in mathematics classroom?

.....

2. How ICTs can be integrated in mathematics classroom?

.....

3. How ICTs integration in mathematics classroom can help teachers?

.....

4. What are the problems of ICTs integration in mathematics classroom?

.....

5. How those problems can be solved?

.....

Thank you

Appendix-VI

Classroom observation guideline

Respected sir/madam and dear students, Me Ranadhir Kumar Sah. I am here with Degree of Master of Philosophy in Mathematics Education research work. This will be focused on the practices of ICTs' in mathematics classroom. I will take many key notes during this period. I want to ensure you all that this information will be used only for academic purpose.

I will follow the following steps to observe your class.

Formal request to headteacher.

Formal meet with teacher participant whose class is being observed.

Consent from all of them.

Preparation for note keeping.

Classroom observation.

Flexible checklist.

Activities of teachers.

Activities of students.

Photo and audio record.

Making notes.