

**TEACHERS' EXPERIENCES AND STUDENTS' PERCEPTIONS
OF ICT INTEGRATED PEDAGOGICAL PRACTICES IN
HIGHER EDUCATION MATHEMATICS**



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**A Dissertation for the Degree of Doctor of Philosophy (PhD) In
Mathematics Education**

Submitted to
Graduate School of Education
Office of the Dean, Faculty of Education
Tribhuvan University, Kathmandu, Nepal

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MATHEMATICS



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By

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Abstract



This research entitled “Teachers’ Experiences and Students’ Perceptions of ICT Integrated Pedagogical Practices in Higher Education Mathematics” aims to explore the information and communication technology (ICT) integrated pedagogical practices in higher education mathematics classrooms of Tribhuvan University (TU) and its impact on pedagogical process focusing on teachers’ experiences and students’ perceptions. The theoretical perspectives of social Constructivism and Connectivism have guided the research paradigm in this study. These two perspectives support the idea of knowledge construction through technology mediated instructional practices and center the learners as autonomous individuals for decision-making with multiple subjective realities. This study applied convergent parallel design under mixed methods research approach. To collect data, 18 mathematics teachers and 240 mathematics students from 12 constituent campuses of Tribhuvan University were selected using multi-stage sampling. The data were collected using multiple tools: classroom observation protocol, interview guidelines, focus group discussion (FGD) guidelines, and survey questionnaire. The qualitative data was analyzed thematically using ATLAS.ti software and quantitative data were analyzed using SPSS 2020.

The study found positive perceptions of teachers’ and students’ towards the use of ICT integrated pedagogy. The perception of students towards the use of ICT in mathematics learning did not differ significantly by their gender, discipline, location of campus, and level of the program they were enrolled. However, significant difference was found in the input of ICT resources, implementation status and output of the ICT integrated pedagogical practices. Reporting low correlation between the input of ICT integrated pedagogy and its implementation in real classroom, the study concluded that there is inadequate implementation of ICT integrated pedagogy in



mathematics classroom at higher education. The result shows that there is positive impact of general practice of ICT by the students, input, and implementation of ICT resources on output of ICTIP. The total of 17.7% of the variance in output of ICTIP can be explained by the combine effect of different constructs of input.

The ICT integrated learning opportunities promoted equity in classes by providing multiple means of engagement and activities for learners who are weak in mathematics. On the whole, the application of ICT tools contributed to the pedagogical transformation, that is, there was a shift from excessive dependency on teachers to flexible and independent learning engagement of students using mathematical software. It further contributed to resourceful learning for all learners irrespective of their current time and space that enabled flexible and diverse learning opportunity. Likewise, this mode of pedagogy improved their motivation for learning, helped enhance creativity and collaboration, and supported conceptual understanding. The ICT integrated pedagogy was also used as an alternative means of instruction during and after COVID 19 pandemic. This form of learning created meaningful interaction, sharing of ideas, and expanded the level of comprehension. This innovative method made learning more creative by assisting students in connecting mathematical ideas to real world situations outside of their classroom.

This study also observed major challenges like: inadequate ICT training, lack of proper institutional support, limited internet and electricity facility, lack of genuine mathematical software and lack of resources for productive utilization of ICT tools in teaching-learning process. In order to address these challenges in relation to access, policy and practice, there is a need to have ICT resources and competent teachers to handle the resources. These findings imply that the ICT integration in mathematics learning activities is needed in the higher education institutions of Nepal.



उच्च तहको गणित शिक्षामा सूचना तथा सञ्चार प्रविधिसम्बद्ध शैक्षणिक अभ्यासमा

शिक्षकहरूको अनुभव र विद्यार्थीहरूको धारणा

शोधसार

“उच्च तहको गणित शिक्षामा सूचना तथा सञ्चार प्रविधि सम्बद्ध शैक्षणिक अभ्यासमा शिक्षकहरूको अनुभव र विद्यार्थीहरूको धारणा” शीर्षकको यो अनुसन्धानले त्रिभुवन विश्वविद्यालयको उच्च तहको गणित शिक्षाका कक्षाहरूमा सूचना र सञ्चार प्रविधिसहितका शैक्षिक क्रियाकलाप एवम् शिक्षकहरूको अनुभव र विद्यार्थीहरूको ज्ञानग्रहणका बारेमा पार्ने प्रभावको अन्वेषण गर्ने उद्देश्य राखेको छ । सामाजिक रचनावाद (Social Constructivism) एवम् कनेक्टिभिजम (Connectivism) को सैद्धान्तिक दृष्टिकोणबाट यो अध्ययन निर्देशित छ । यी दुईओटा दृष्टिकोणले प्रविधिप्रयुक्त शैक्षणिक अभ्यासमार्फत् ज्ञाननिर्माण गर्ने नीतिलाई पक्षपोषण गर्दछन् एवम् शिक्षार्थीहरूलाई उनीहरूको व्यक्तिगत जीवनका वास्तविकताका आधारमा निर्णय गर्न सक्ने स्वतन्त्र व्यक्तिका रूपमा प्रस्तुत गर्दछ । यस अध्ययनमा अनुसन्धान पद्धतिका मिश्रित विधिअन्तर्गतका अभिसरण समानान्तर डिजाईन (convergent parallel design) को प्रयोग भएको छ । तथ्याङ्क सङ्कलन गर्दा बहुचरणीय (multi-stage) नमुना छनोट विधिअनुसार त्रिभुवन विश्वविद्यालयका १२ ओटा आङ्गिक क्याम्पसका १८ जना शिक्षक र २४० जना गणित विषय अध्ययन गर्ने विद्यार्थीहरू छनोट गरिएको थियो । यस अध्ययनमा कक्षाकोठा अवलोकन प्रोटोकल, अन्तर्वार्ता निर्देशिका, लक्षित समूह छलफल (FGD) निर्देशिका र सर्वेक्षण प्रश्नावली जस्ता विविध अनुसन्धान साधन प्रयोग गरेर तथ्याङ्क सङ्कलन गरिएको थियो । गुणात्मक तथ्याङ्कलाई ATLAS.ti सफ्टवेयर प्रयोग गरेर विषयगत रूपमा विश्लेषण गरिएको थियो र परिमाणात्मक तथ्याङ्कलाई SPSS 2020 प्रयोग गरेर विश्लेषण गरिएको थियो ।



यस अध्ययनले सूचना तथा संचार विधि (आइसिटी) सम्बद्ध शिक्षणविधिको

अवलम्बनप्रति शिक्षक र विद्यार्थी दुवैको सकारात्मक धारणा रहेको देखाएको छ ।

गणितशास्त्रको अध्ययनमा आइसिटीको प्रयोगप्रति विद्यार्थीको लिङ्ग, विषयगत क्षेत्र, कलेजको अवस्थिति र उनीहरू भर्ना भएको तह फरक भए तापनि लगभग समान धारणा रहेको पाइयो तर आइसिटीसम्बद्ध स्रोतको लगानी (input) मा, कार्यान्वयन तहमा र आइसिटीसम्बद्ध शैक्षणिक अभ्यासबाट हुने प्रतिफल (output) मा भने महत्त्वपूर्ण भिन्नता रहेको पाइयो । आइसिटीसम्बद्ध शिक्षणशास्त्र र कक्षाकोठामा यसको कार्यान्वयनबिच कम सहसम्बन्ध (low correlation) रहेको प्रतिवेदन दिँदै यस अध्ययनले उच्च तहका गणित कक्षाहरूमा आइसिटीसम्बद्ध शिक्षणविधिको कार्यान्वयन अपर्याप्त रहेको निष्कर्ष निकालेको छ । यसको नतिजाले विद्यार्थीहरूले आइसिटी प्रयोग गरेका सामान्य अभ्यास, आइसिटीसम्बद्ध शैक्षणिक विधिको प्रतिफलमा इन्पुट तथा आइसिटी एकीकृत शिक्षण पद्धतिको कार्यान्वयनको कक्षाकोठामा सकारात्मक प्रभाव रहेको देखाएको छ । आइसिटीसम्बद्ध शैक्षणिक विधिको प्रतिफलमा देखिएको भिन्नताको कुल १७.७ प्रतिशतलाई इन्पुटका विभिन्न आयामहरूको संयुक्त प्रभावद्वारा व्याख्या गर्न सकिन्छ । आइसिटीसम्बद्ध सिकाइ अवसरहरूले गणित विषयमा कमजोर विद्यार्थीलाई पनि सिकाइ प्रक्रियामा संलग्न हुने बहुविध साधन एवम् क्रियाकलाप उपलब्ध गराएर समताको अभिवृद्धि गर्न मद्दत गरेको पाइयो । समग्रमा भन्नुपर्दा आइसिटी साधनले शैक्षणिक रूपान्तरणमा उल्लेखनीय योगदान पुऱ्याए । भनाइको तात्पर्य विगतमा जस्तो शिक्षकमाथिको निर्भरताबाट गणितीय सफ्टवेयर प्रयोग गरेर विद्यार्थीको सिकाइमा लचकता एवम् स्व-संलग्नतातर्फ बदलिएको छ । यसले लचिलो र विविध सिकाइ अवसरलाई सक्षम तुल्याउने विषयलाई वास्तै नगरी सबै विद्यार्थीका लागि साधनसम्पन्न सिकाइमा योगदान पुऱ्यायो । त्यसैगरी अध्यापनको यो मोडलले उनीहरूको



सिकाइप्रतिको प्रेरणालाई सुधायो र पारस्परिक सहकार्यलाई बढाउन मद्दत गयो र अवधारणागत बोधशक्तिलाई पक्षपोषण गयो । प्रविधि सम्बद्ध शैक्षणिक विधि कोभिड-१९ महामारीको अवधिमा र त्यसपछि पनि शिक्षणको वैकल्पिक माध्यमका रूपमा पनि प्रयोग भयो । सिकाइको यो स्वरूपले अर्थपूर्ण अन्तरक्रिया, विचारको आदानप्रदान गर्ने अवसर प्रदान गयो र बोधशक्तिको स्तरलाई विस्तृत तुल्याएको छ । यस नवीन विधिले विद्यार्थीहरूलाई कक्षाकोठाभन्दा बाहिरको वास्तविक परिस्थितिमा गणितीय विचार जोड्न मद्दत गरेर सिकाइलाई थप रचनात्मक बनायो ।

यस अध्ययनले अपर्याप्त आइसिटी तालिम, उचित संस्थागत सहयोगको अभाव, इन्टरनेट तथा विद्युत्को सीमित सुविधा, वास्तविक गणितीय सफ्टवेयरको अभाव र शिक्षण-सिकाइ प्रक्रियामा आइसिटीको प्रभावकारी कार्यान्वयनका लागि चाहिने साधनको अभाव जस्ता चुनौती पनि यस अध्ययनका क्रममा अवलोकन गरिएको थियो । पहुँच, नीति र अभ्याससम्बन्धी यी चुनौतीलाई सम्बोधन गर्न आइसिटी साधन र तिनको परिचालन गर्न दक्ष शिक्षकहरूको परिपूर्ति आवश्यक छ । यी निष्कर्षले नेपालको उच्च तहका शैक्षिक संस्थाहरूमा गणित सिकाइ क्रियाकलाप सूचना तथा सञ्चार प्रविधिमा आधारित हुनुपर्छ भन्ने कुराको सङ्केत गर्दछ ।

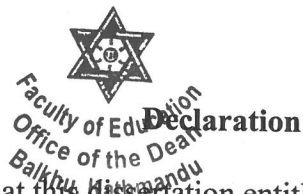


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**Declaration**

I hereby declare that this dissertation entitled '**Teachers' Experiences and Students' Perceptions of ICT Integrated Pedagogical Practices in Higher Education Mathematics**' submitted to the Graduate School of Education, Office of the Dean, Faculty of Education, Tribhuvan University, Nepal for the degree of Doctor of Philosophy (PhD) is my original research work and has not been submitted in part or in full for any other degree to any other Universities. Other sources of information have been acknowledged where they have been used.

Date: December 18, 2024 (2081-09-03)

Lok Nath Bhattarai



Recommendation Letter

It is my pleasure to certify that Mr. Lok Nath Bhattarai, has prepared and submitted his dissertation entitled '**Teachers' Experiences and Students'**

Perceptions of ICT Integrated Pedagogical Practices in Higher Education

Mathematics' for the Doctor of Philosophy (PhD) degree in Mathematics Education.

I have found the dissertation to be in conformity with the required standard prescribed

by the Graduate School of Education, Faculty of Education, Tribhuvan University

Kathmandu, Nepal. Therefore, I recommend the dissertation to the Research

Committee of the Faculty of Education for acceptance.

Supervisor

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Date: December 19, 2024



Approval Letter

This dissertation entitled 'Teachers' Experiences and Students' Perceptions of ICT Integrated Pedagogical Practices in Higher Education Mathematics' presented by Mr. Lok Nath Bhattarai to the Faculty of Education for the Degree of Doctor of Philosophy (PhD) has been approved.

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Abbreviations

ANOVA	Analysis of variance
B.Ed.	Bachelor of Education
BCA	Bachelor of Computer Application
B. Sc. CSIT	Bachelor of Science in Computer Science and Information Technology
CALL	Computer Assisted Language Learning
CAMT	Computer Application in Mathematics Teaching
CDC	Curriculum Development Centre
CDED	Central Department of Education
CK	Content Knowledge
DOE	Department of Education
F2F	Face to Face
FGD	Focus Group Discussion
FOE	Faculty of Education
ICT	Information and Communication Technology
ICTIP	Information and Communication Technology Integrated Pedagogy
IT	Information Technology
KU	Kathmandu University
MKO	More Knowledgeable Other
MOOC	Massive Open Online Course
M. Ed.	Master of Education
MoE	Ministry of Education
MoCIT	Ministry of Communication and Information Technology
MOODLE	Modular Object-Oriented Dynamic Learning Environment
NCED	National Centre for Education and Development

NGO	Non-Government Organization
NCTM	National Council of Teachers of Mathematics
ODEC	Open and Distance Education Center
ODL	Open and Distance Learning
PCK	Pedagogical Content Knowledge
PK	Pedagogical Knowledge
SES	Socio Economic Status
SPSS	Statistical Package for the Social Sciences
TCK	Technological Content Knowledge
TPCK	Technological Pedagogical and Content Knowledge
TPK	Technological Pedagogical Knowledge
TU	Tribhuvan University
UNESCO	United Nations Educational, Scientific and Cultural Organization
WWW	World Wide Web
ZPD	Zone of Proximal Development

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Chapter One

Introduction

This chapter presents the context and background of the study, statement of the problem, objectives of the study and research questions. It also discusses the delimitations, significance of the study, and definition of key terms.

The Context

As a novice teacher, I started my teaching carrier at Central Department of Education, Tribhuvan University (TU), Kirtipur, Nepal in 2005. At the beginning, I often used lecture method while teaching. While delivering lectures to the large classes, I also used chalk to write on the blackboard. After few years, the blackboards were replaced by whiteboards and chalk by board-markers. Beside these shifts, most of the classes were equipped with multimedia projectors with free but limited Wi-Fi facilities for teachers and students within department premises. This shift aroused an interest to develop technological competences within myself and I started to use laptop, multimedia projector, pen drive and other different digital devices as teaching/learning resources. I also used different mathematical softwares like GeoGebra, Mathematica, MatLab, SPSS, Excel, C programming and pedagogical tools like Moodle (modular object-oriented dynamic learning environment), MS Teams, Zoom and Google classroom as Information and Communication Technology (ICT) tools and ICT integrated pedagogy (ICTIP) for teaching mathematics. Beside these, different messenger groups or WhatsApp groups, personal email and Viber were also used to facilitate students learning. Using any of the media mentioned above, students could communicate and put queries about their subject matter with teachers on their comfortable time and zone.

The anecdote above is an example of how educational technology changes and technology integrated pedagogy is subsequently changing the field of teaching and learning in higher education in Nepal. In this era, the possibility of rapid transformation in pedagogy in using technology can be expected from teachers and students. Emergence of ICT integrated pedagogy in education has challenged the traditional learning theories, instructional strategies, and pedagogies used in teaching and learning in higher education as well (Dhakal, 2019). ICT integrated instructional strategies and pedagogical practices have been found more effective for the students who are unable to attend their face-to-face classes regularly due to different circumstances and especially for all the students during COVID 19 pandemic (Dhamala, 2020).

The rapid development in ICT these days resulted the change in the daily life activities and communication style on educational institutions. This type of development in technology impacts on educational system both in terms of content and delivery service of education. It creates pressure on decision-makers to bring in new technologies in the field of education. At the same time, different ICT tools and techniques, like Google, Viber, You-Tube, Messenger, Web 2.0, and Web 3.0 were also rapidly developed. This type of technological development brings awareness on policy maker as well. In order to enhance the quality teaching learning using technology, we need to be aware of how ICT based pedagogy contributes in the development of education system.

The ICT based pedagogy was broadly used by educational institutions all over the world during COVID 19 pandemic period (Niroula, 2021). Different online platforms like Zoom, Google Meet, group Messenger and Microsoft Teams were used to conduct classes in each campus of TU (TU, 2020). Teaching and learning from

distance mode was an alternative at that period when the whole world was affected by the infectious disease. In this regard, TU decided to run the classes of Bachelor and Masters level using online mode. To conduct the online classes effectively, TU issued two separate guidelines; 'Online Class Guidelines' and 'Electronic Communication Management Guidelines' with the objective to developing official mail for all teachers and students and deciding to run their classes using MS Teams (TU, 2020). This decision helped to develop uniformity on online classes and all the classes were controlled from the central office. This also brought universities from around the world closer than before which was one form of internationalization. In addition to teaching and learning online, TU planned to implement digitalization of administrative and financial system in order to make the university entirely paperless and quick functioning (Dhamala, 2020).

Many constituent and affiliated campuses of TU also developed infrastructure as well as learning environment for online mode of teaching. Teachers and students were provided with professional training to cope with this situation. This situation required ICT integrated pedagogy for teaching mathematics effectively. This also helped in implementing digitalization of administrative and financial system in order to transition to a paperless and quick functioning service at the university. To develop competences for online classes, majority of teachers and students were trained. The teaching and learning modality was changed for new context. This development in pedagogy suggests that ICT tools are the most important factors for educational institutions to embrace changes.

So, this study identified the present conditions of ICT infrastructure on constituent campuses of TU and explored the perceptions of students and experiences of teachers on the practices of ICT integrated pedagogy in higher education

mathematics classroom. In this context, the study results are expected to be useful to utilize ICT Integrated Pedagogy (ICTIP) in the context of higher education mathematics classes. Beside this, the result of this study shows ICTIP as a desirable method to promote equity and create better learning opportunities for all students in mathematics classes through pedagogical transformation.

Background of the Study

The use of ICT integrated pedagogy in mathematics teaching has received considerable attention in Nepal. This is an emerging issue for effective mathematics teaching to help students learn mathematics. ICT integrated pedagogy is practiced in a mathematical laboratory that develops learners' mathematical knowledge in a practical way. For this reason, ICT became a valuable teaching tool as it offers ample possibilities of learning. It can produce significant changes in teaching methods and the way in which students can access and interact with the mathematical knowledge (Spector & Johnson, 2014). So, new technology can enhance the capacity of students and make the classroom environment natural as well. The ICTIP has been established as the teaching learning process where the students have the access to teachers' class presentations while they need, with flexibility of time and space (Bhattarai, 2019). Due to such flexibility, students can watch teachers' recorded class presentations at their home using ICT tools and solve the assignments provided.

ICT permeates modern societies. The role of ICT in the development of literacy and numeracy is crucial as a basic education. ICT is not only the new subject for learners in their learning process but is used as a valuable tool for quality education. For example, the use of mathematical software can provide the best way to solve large mathematical problems in a short period of time and the simulation and

visualization through the use of technology can help mathematics students to learn and remember complex and abstract concepts of mathematics in simple ways.

An examination of countries like Nepal has shown that the technology is not being used massively in the teaching learning process (UNESCO, 2015). The little use of ICT is due to capacity-related and technical problems. So, for the effective implementations of ICT we need to address to overcome these problems. As of now, in Nepal there is no specific policy to make ICT compulsory in educational institutions due to the inadequate infrastructure, technical support, and connectivity. Rather, ICT has often been used bit little in pedagogical practices. So, in order to fulfill the need of 21st century society and interest of students, ICT must be fully integrated in teaching learning process, that requires pedagogical transformation on the part of administrator, and policy maker.

During the last two decades, educational practices are continually growing with the use of innovative technology. New techniques such as e-learning, o-learning, v-learning, blended learning, hybrid learning, M-learning, and MOOC have emerged to represent technology integrated educational practices (Dhakal, 2019). Therefore, the practical teaching learning process based on technology such as use of powerpoint presentation and use of several applications can make mathematics pedagogy effective. This leads towards a considerable change in teaching- learning process from traditional approach to the modern educational system in mathematics classes. In this regard, it is imperative to explore the extent to which the integration of ICT into mathematics teaching contributes to better learning opportunities for all students regardless of their sex, ethnicity, and socio economic status. As the access on technology increases at homes and educational institutions, it is necessary to investigate the extent to which the variation on access and use of technology widens

the gap between the performance of institution, teachers and students. Beside these, the issues of transition from the traditional method to ICT-integrated pedagogy and exploration of the ways teachers and students adopt this newer approach in their teaching and learning practices has not been adequately researched in the context of Nepal. It is, therefore, necessary to analyze how far the ICT integrated pedagogy in higher mathematics classes is practiced by mathematics teachers in their pedagogical process and helps to address the issues of equity and pedagogical transformation in mathematics classes.

Mathematics and Technology

With the beginning of 21st century, technology has had a profound effect on teaching and learning process. Most of the effect was focused on how technology can enhance education in order to replace teacher dominant teaching tradition and reduce large number of human resources. In fact, implementation of technology in the field of teaching and learning is one of the main steps to think about while aiming at replacement of the traditional chalk and talk method. On the other hand, educational technology is defined as technological tool and media that assist in the communication of knowledge to the related field, its development and exchange (Spector & Johnson, 2014). It is important and useful system to access mathematical knowledge by learner without depending on their teachers as well.

It is stated that the use of technology in teaching and learning mathematical concepts has made a positive contribution to students' learning and their motivation (Baki 2000; Lin, 2008). At present, ICTs have become the inevitable parts of any human activities. This has brought positive impact on all aspects of human life. ICT based pedagogy have become effective within a very short time, as a basic building blocks of modern society (Daniels, 2002). Therefore, the field of mathematics and

social sciences too cannot be an exception of it. The use of ICT tools and techniques in mathematics pedagogy has affected the perceptions of learners, their motivation and intuition. In this context, we need to adjust and adapt ourselves this modern and technological environment. Further, if we observe activities of our students in the higher mathematics classroom, their classroom participation is low. This shows that, there is greater dependence of students on their teachers and the limited information and resources that their teachers provide for learning. This leads to the passivity in their classroom, resulting in their lower confidence. In this regard, ICT integrated pedagogy in mathematics class has the potential to innovate, enrich, and develop deeper skill to motivate students, helps them to relate learning experiences of their institutions (Davis, 2001).

The increasing use of technology based pedagogical practices has positive impact on improving students' learning experience in mathematics. Hall and Chamblee (2013) have mentioned that the use of technology has created new possibilities to edify and visualize mathematical ideas that students really care about. In this regard, Nardi (2007) gives numerous examples. He has mentioned that mathematics departments of many universities have modified their syllabus that emphasized the use of technology in teaching and learning. Universities have adopted ICT integrated pedagogical practices in their curriculum as well. It is also justified in the work of Wood, Petocz, and Reid (2012) that mathematics educators and mathematics departments have begun to use technology to improve students' learning achievement and experiences.

Technology in mathematics permits discovery and innovations in the field of teaching and learning. It is mentioned that "if students can program a machine to do and display mathematical contents, then at first they have to understand that content

properly” (Winkel, 2013). Then the students can learn the concept meaningfully by the help of technology. This indicates that, technology integrated pedagogy can be a meaningful approach in mathematics learning that helps students to understand and visualize the abstract concepts of mathematics easily and clearly. Once students understand the mathematics content meaningfully, it is more probable that they can use it for further learning, which is the essence of effective learning.

Use of technology in mathematics enhances the learning opportunity. With this belief, mathematics educators have started to use varieties of technologies to support and enhance students’ learning in mathematics since last three decades (Borba & Weigand, 2015). Some examples of these technologies that many teacher educators have been using in mathematics teaching are GeoGebra, Mathematica, MatLab, Latex, C programming, SPSS, etc. The purpose of these technologies in the process of teaching and learning mathematics is for visualization, simulation, data analysis, modeling and other pedagogical activities. With these technologies, mathematics educators are trying to explore mathematical ideas for meaningful concepts and visualization. However, the experiences of teachers and perception of students about the practice of such technology integrated pedagogy and its impact on education has not been researched and documented in the teaching learning process. In addition, the ways these ICT tools as teaching-learning resources address the issues of equity and pedagogical transformation in teaching learning process contribute to learn mathematics in higher level, is yet to be researched. Therefore, I feel it is important to contribute to this research gap through this research.

In the context of Nepal, the constituent and affiliated campuses of different universities have been offering higher education in different disciplines. Besides, many other courses, both ICT-based education and ICT education are being run as the

components of curriculum in the universities and colleges in Nepal (TUFOE, 2015). The integration of ICT in education system can be seen in the M.Ed. and M. Phil. programs run by Kathmandu University (KU) (Wagley & Jha, 2013) and B. Ed., M. Ed. and M. Phil. leading to Ph.D. programs run by Tribhuvan University. Likewise, KU has run Computer Application in Mathematics Teaching (CAMT) and Computer Assisted Language Learning (CALL). It has also offered E-learning series based on MOODLE and web 2.0. Both Tribhuvan University and Kathmandu University have run computer sciences or computer engineering degrees at bachelor level. Recently, TU has started M. Ed. in English, Mathematics, and Foundation of Education through open and distance learning (ODL) mode utilizing ICTs after the establishment of ODEC on 2015. The courses 'ICT in Education' and 'ICT in specialized subject' have been prescribed as the elective courses under the 'professional core courses' as provisioned in the revised B. Ed. programme.

Policy and Practice of ICT in Higher Education

ICT tools are supposed to have multiplier effect in the education system because they can enhance learning and can provide learners with new set of skills. That is why many countries have developed ICT integration policy in their national education curricula at all levels; primary, lower secondary, and upper secondary (Wallet, 2014). It is necessary to provide the citizens of any country with appropriate knowledge, skills, and attitude to involve them actively in development initiatives. The long-term objective of education in Nepal is to integrate the country into the global community by providing quality education for all. MOE (2013) declared, "Use of ICT in education has been considered as one of the strategies to achieve the broader goals of education" (p. 3). ICT in education has been addressed in various

plans, policies, and programmes in Nepal though the strategies determined have not been effectively implemented and the objectives have not been fully achieved.

In the context of Nepal, the first government policy document that aimed to lunch information technology into educational institutions with various purposes including distance learning, is the IT policy 2000 (Nepal Telecommunication Authority, 2012). However, there is gap between the policy and practices of ICT tools and techniques in education. The National Curriculum Framework 2005 also included ICT to be integrated into educational institutions as a tool and to be taught as a separate subject (MOES, 2005). In this regard, the revised curriculum 2007 has also the same objectives in the context of ICT integration (MOES, 2007). Likewise, the School Sector Reform Plan 2009-2015 also emphasized the integration of ICT tools as a learning activities in higher education but unfortunately there was no funding for ICT infrastructure and training for ICT users. The ICT in Education Master Plan 2013 again emphasized the integration of ICT based pedagogy in higher education as well as school education (MOE, 2013). The School Sector Development Plan 2016 – 2023 is another policy document in favour of ICT integrated pedagogical practices in educational institutions helping on the transform of traditional pedagogy to ICT integrated pedagogy (MOE, 2016). For this, Nepal government took technology initiatives, including strengthening ICT infrastructure at schools and universities; ICT-enabled teaching and learning; and integrating education management information system (EMIS) as part of the SSDP 2016–2023 program (MoCIT, 2019).

However, the study report of Rana (2018) indicates that there are several hundred primary schools, which have adopted technology integrated instruction in their pedagogical process, and that the educational institutions have been trying to shift their traditional pedagogical practices into the modern techniques. The study also

indicates that Nepal government has in the primary phase of developing strategies to provide ICT tools for educational institutions and training for the stakeholders to use ICT. In this context, Nepal government has involved several non-governmental organizations (NGOs) to fund for ICT infrastructure and training for teachers to develop their skills for using ICT effectively.

The integration of ICT in teacher education, in-service teachers training programme, and school teaching was emphasized by ICT in Education Master plan-2013 (MOE, 2013). In this regard, the universities of Nepal also have to systematize the use of ICT integrated instruction in their higher education programmes (Rana, 2018). In addition to these initiatives in higher education, Nepal Open University (NOU), Open and Distance Education Center (ODEC), TU have recently put ICT integrated pedagogy into practice. As the majority of the population lives in the rural areas and the internet connectivity is not reliable, use of ICT in education has been a far reaching dream for some students. A study by Neupane (2018) reveals that in mid-2018, about 63 percent of the total population of Nepal had an access to internet, that was recorded 58.72 percent in 2017 and 50.11 percent in 2016. The facts and statistics show that the ICT status in Nepal among other South Asian countries is relatively low. It is necessary to review the national plans and the policies that have been developed to have more far-sighted policies and strategies for the improvement of the existing situations.

However, Tribhuvan University has Bachelors and Masters programmes such as “ICT in Education”, “BCA”, and “BSc CSIT”, more ICT friendly curriculum than others, but the courses are more technical and much focused on teaching computer programmes. This shows that the use of modern technologies and technology-integrated teaching learning is rapidly increasing in education, particularly in higher

education (Rana, 2018). However, the rapid development and application of ICT tools and techniques have been pressing every individual to acquire foundational literacy in ICT, and its importance in education is significant.

The Context of Higher Education Mathematics Classroom

Tribhuvan University in Nepal is the first, largest and oldest university bearing about 82% responsibility of higher education (MoE, 2017). It has aimed at providing internationally competitive quality of education through several programs in sciences, technical and medical education. To ensure the quality education, the university has taken several initiatives to integrate ICT in teaching. There are some applied, some pure and some pedagogical mathematics courses in bachelor and master's programmes under Faculty of Education (FoE), TU. But, there are only pure and applied mathematics courses in bachelor and master's programme under Institute of Science and Technology (IoST), TU. The past enrollment record of students shows that the majority of students from remote areas of the country and middle class family are enrolled in constituent campuses of TU. The educational institutions of TU these days focus on the transformation of pedagogical and content knowledge for teaching-learning and research activities, serves quality mathematics, and supports academic collaboration at national and international levels to faculties and students. The higher level mathematics education classrooms are multicultural as the students are from various geographical regions of Nepal representing diverse social, cultural and economic backgrounds. However, the enrollment of female students in mathematics is very low in comparison to other academic disciplines at TU.

Mathematics classrooms in Nepal are diverse in general because students come to the university from different cultural and socio-economic backgrounds. This context has resonated what Gates (2006) expressed, "in many parts of the world,

mathematics teachers are facing the challenges of teaching in multi-ethnic and multi-dimensional classrooms containing -immigrant, indigenous, and intellectual level children, and if research is to be useful it has to address and help us understand such challenges" (p. 391). I agree with Gates' opinion that mathematics classroom situation in Nepal is same as stated above because different socio-economic background, multi-cultural nature and intellectual level of students have their own personal problems in a classroom context. The enrollment of mathematics students in the academic year 2020/21 at Department of Mathematics Education, University Campus, Kirtipur revealed that 50 students in a master level class belonged to 18 different caste and ethnic groups from more than 25 communities. Beside these, the students have different culture, different interest and different achievement level. This scenario is the major cause's inequality in mathematics classes and students' learning. The different nature of students in a single class creates problem to maintain the equality issues in teaching mathematics.

Mathematics as a discipline in educational practices is less considered as a pleasing subject (Erdogan, Yazlik, & Erdik, 2014). The beliefs of people towards mathematics as tedious subject has been developed because of many reasons, conceptions and misconceptions that have evolved in the community. As a consequence, the discipline is heavily impacted gaining its popularization in its thinking, doing and execution (Dhakal, 2019). On the other hand, the traditional pedagogy used by teachers in higher mathematics classes creates anxiety and fear on students (Erdogan, Yazlik, & Erdik, 2014). So, questions such as a) What type of pedagogical practices do teachers apply in teaching mathematics? b) Does the pedagogy adapted by teachers in the current time help to manage the equity issues of students in a single classroom? and c) What strategies help teachers to make

pedagogical transformation in mathematics education? arises frequently. These questions became central to me to identify and explore a more meaningful pedagogy for the 21st century that transforms the traditional method of teaching to the modern one by integration of ICT in pedagogy. Hence, the exploration of the experiences of teachers and perceptions of students in the practices of ICT integrated pedagogy in mathematics teaching is important.

Paradigm Shift in Pedagogy

The integration of ICT into pedagogical practices brought some changes in teachers' and students' role in higher education mathematics. The traditional learning approaches based on structuralism were mostly focused on rote learning and practices for knowledge transmission to the learners. Conversely, the modern student-centric constructivist pedagogical practices promote active knowledge construction on learners employing technology (Harasim, 2012). In this modern approach, learners use technology to develop clear concepts on given content, answer related questions and solve necessary problems meaningfully. For this, teachers' role is a guide and is expected to facilitate the learners to ensure the meaningful learning (Prensky, 2012). Moreover, this new paradigm helps learners to develop their skills in order to be competitive, critical thinker, innovative creator, effective communicator and collaborator to compete in this digital era (Gunn & Hollingsworth, 2013; Robinson, 2015). In this regard, the changing paradigm in teaching learning process changes the role of teachers and assign them in terms of connecting students' learning as a guide and facilitator (Prensky, 2012). Moreover, he opines that the changing role of teachers in 21st century is also influences the personal life of students' in which "The onus is then completely on the students... it emphasizes that the roles of each group, teachers and students, are different, but equal" (pp. 14-15).

The ICT integrated pedagogical practices could facilitate the changing roles between teachers and students such that these innovative techniques helps for anytime anywhere learning opportunity for the students (Hassel & Hassel, 2011). Hassel and Hassel conclude that ICT integrated pedagogy makes the role of teacher much flexible such that they could give feedback to their students of remote places timely through messenger, email, Viber, or other technological means. Likewise, the students could also report teachers about their problems and learning activities using any digital medium. Thus, ICT is essential for teachers to adopt students centered pedagogy in their teaching learning process that promote self-learning and motivation. But, a study by Rana and Rana (2020) reported that only making technology available in their classroom and providing essential ICT training for teachers cannot assure the integration of ICT in their pedagogical practices effectively.

The pedagogical transformation empowers learners to engage in collaboration to co-construct meaning from ICT based media and materials and experiences through an inquiry-based approach. It helps to promote personal experiences of learners, dialogical pedagogy, and equity in the classroom. Moreover, the transformed pedagogy was not just a combination of different tactics, but was a pedagogy that took into careful consideration of student understanding, classroom structure, and contextual demands (Carol, 2008). This type of technology-based class is more effective for the students who are unable to attain their face-to-face class. In the present context, most of the face-to-face classes have been replaced by online classes. This change offers mathematics teachers to be aware of the recent paradigm of teaching and learning mathematics by participating in various online workshops and webinars.

Role of Technology Integrated Pedagogy for Promoting Equity

According to Leder (1992), equity refers to the access for all concerned regarding societal and personal accomplishments, as well as economic reward. Equity provides the freedom for learners to choose learning center and career activities without social censure. The common assumption in the society for addressing equity issue is the development of mathematical concepts effectively by the use of technology integrated pedagogy. This is also a growing concerns in present digital era. But, how to adopt the technology in teaching mathematics is rarely discussed in academia. There are many ways, methods and techniques to integrate technology in educational practices especially in learning mathematics. These varieties are due to the varieties in technologies, for example, pedagogy related technology, content related technology, communication related technology, and assessment related technology. These varieties of technologies also include computer technology, internet technology, and web technology that are used to help students to enable their independent learning.

Moreover, the use of ICTs in the classroom appropriately fosters critical, integrative and contextual teaching and learning. Thus, it improves the overall efficiency of the delivery of education in higher level and educational management in institutions of national, provincial and local level. The use of ICTs in teaching learning process aims to improve the quality of education as well as democratize the access to education for learners. The ICT has a vital role in connecting the community of diverse students to global world. It also helps them in exchanging information and fulfills the basic necessity for learning resources. Effective use of ICT crosses the geographical boundaries and can bring students from rural communities closer to

global learning communities through online platforms, like MOOC and provide meaningful help to the learners of underprivileged and diverse society.

In this study, equity encompasses access such as physical access, inclusion, capacity building, multicultural realism and diversity, and it may also involve special services (Powell, 1994). In 2000, the National Council of Teachers of Mathematics (NCTM) published the equity principle, outlining that achieving equity for all students necessitates raising learning expectations, developing effective support methods for mathematics education, and providing necessary resources for both teachers and students. Powell (1994) described equity in the most comprehensive way, stating it means addressing each student as an individual with instructional opportunities, content, and tailored to their specific needs, strengths and interests. It aims all students should be engaged in meaningful learning within an institutional framework that values diversities and encourages active participation in the learning process (p. 3).

Building on the significance of high expectations, effective teaching, the equity principle clarifies that it should not be confused with equality. It does not mean that all students receive the same instruction or the same amount of instructional time (Hill, 1991). Rather, the principle advocates for suitable accommodations, diverse learning opportunities, high expectations, and sufficient resources and support to ensure that all students achieve equitable outcomes (Krueger & Sutton, 2001 as cited in Sharma, 2007, p. 177).

In this regard, ICT integrated pedagogy can address different dimensions of students; create equal opportunities on learning and transformation on learning style. One of the common phenomenon of equity is to manage the diversity of students in the classroom. In this situation, the best practices of technology-based teaching

learning environment are helpful for creating equal opportunities in the mathematics classroom.

Statement of the Problem

There are several issues and concerns that are critical for the application of ICT in teaching in general and mathematics teaching in particular. Some researchers argue that ICT integrated pedagogy as innovative teaching technique, used to produce, store, and exchange information, can restructure teaching methods in the process of education (Trushell, Byrne & Hassen, 2013). Use of ICT integrated pedagogy can contribute to bring a drastic change in the teaching and learning strategy so as to make it more interactive than teacher dominated traditional method (Huang, Kinshuk, & Price, 2014). In other words, ICT based pedagogy has power of providing opportunities for accessing learning resources and information (Asli, Berrado, Sendide & Darhmaoui, 2012).

On the contrary, some research studies (Davis & Hartshorne, 2010; Jena, 2015) have raised serious concern about the efficacy of ICT tools as they require technological and pedagogical competency. Beside this, there are challenges in adoption because they sometimes can become source of distraction and that they are used by the students in an adjunct manner (Trushell, Byrne, & Hassen, 2013).

The traditional goal of education is to ensure students' socialization by getting them to accept existing ideologies, rules and practices in a country or society. The goal of modern and multicultural education is to contribute to the establishment, application and maintenance of social justice and equality and ensure a social transformation in the society. This perspective may be established when we improve our education policy and curriculum. For this purpose, it is necessary to train teachers and teacher candidates in line with this understanding to equip them with basic

competences in using technology in pedagogy. The purpose of this study is to explore the present status and use of ICT based pedagogy as well as teacher's experiences and student's perceptions towards ICT integrated pedagogy in teaching mathematics in higher education mathematics classes.

New development in ICT has had a significant impact on the role of teachers to improve their students' achievement. Many teachers have lack of knowledge and skills to use ICT as a tool to facilitate learning and create ICT-friendly learning environments. The main problem for the effective implementation of ICT in education is the lack of adequate knowledge, skills and attitude on teachers as a facilitator at individual, institutional and national levels. To overcome these problems, many countries launched teacher training programmes for the effective use of ICT, but most of the training activities are not effective and only for the formality. The computer literacy only does not enable teachers to integrate technology with pedagogy and facilitate ICT-assisted interactive teaching-learning at classroom level.

Nepal is practicing the modern innovative developments of this 21st century world. Many of the new tools and techniques that have been already familiar in the developed countries are yet to be introduced in the Nepalese societies given the financial and development strength of Nepal. There are concerns and issues related to how developing countries such as Nepal deal with the problems like ICT infrastructures, poor computer literacy, and access to the Internet, financial and physical support, professional development opportunities, learning resources, interactive and collaborative activities, and skilled manpower. Although universities in Nepal are gradually shifting towards modernization and implementing technology-based pedagogy in the educational systems, there is a knowledge gap on how such technological advancements have been implemented in classrooms in general and

mathematics classroom in particular. Of course, ICT tools and modern technologies are getting popularity in the higher education institutions in Nepal and the significance of ICT integrated pedagogy in education have been realized, and some plans and policies such as SSDP, SSRP for the betterment of ICT integration have been made from both Government and NGO/INGO levels (MOE, 2016).

As per the need of the society and interest of the students, Tribhuvan University has been putting effort to maintain the quality education in different disciplines. With these objectives and the necessity of technology in teaching and learning, little is known about the preparedness and the attitude of faculties of TU to integrate technology in educational practices. The ICT integrated pedagogy address aimed at addressing the learning need of marginalized and diverse community students in higher education.

The available literatures and practices also show that ICT is the best tool to assess students learning (Pilley, 2016). In addition, results of some research studies have established ICT as the best digital tool that facilitates learning mathematics. It has also added the possibility of ICT integrated pedagogy in other disciplines in the future. As a researcher, I see that the mathematics students of higher level need to acquire 21st century learning skills to be a leader of their learning communities as well as contribute to nation building. For this, they need to master communication, creativity and critical thinking skills as 'learning to learn' skills by emphasizing practical knowledge. However, the plans and policies as mentions above have not been satisfactorily implemented and the teachers and students of TU face several obstacles on its way to implementation. The available body of knowledge is inadequate to explain how ICT has been implemented by teachers in mathematics classroom and in what ways the use of ICT contributes to wider learning

opportunities, reducing learning gaps among students and learning transformation in the community school context in Nepal.

Therefore, there is a need of empirical research studies that can arouse cognizance of the stakeholders and that can be helpful to find out the present status and use of ICT-based pedagogy as well as experience of teachers and perception of students about the practices of ICT integrated pedagogy including its effectiveness in higher education mathematics classes that guide the formulation of further strategic plans and policies for ICT development in Nepal.

Objectives of the Study

The study analyzes the experiences of teachers and perception of students towards the practice of ICT integrated pedagogy in higher education mathematics classes with special focus on the issues of equity and transformation. This study has following objectives:

1. to examine the perception of mathematics students towards the implementation of ICT integrated pedagogy in higher education in terms of gender, discipline, level, interest, availability of resources, and location.
2. to determine the effect of general practice and input of ICT on output of ICT integrated pedagogical practices.
3. to explore the mathematics teachers' experiences towards the role of ICT integrated pedagogy in creating equitable learning opportunities for students in higher education mathematics classes.

Research Questions

Research questions, which are the 'conceptual infrastructure' for building the study, raise queries about the research issues of the study (Cohen, Manion & Morrison, 2018). The themes that emerge from data coding and categorizing preserve

the main research questions for the overall study. They indicate the primary information about the phenomenon that the researcher investigates. Similarly, findings that are the outcomes of the study preserve certain activity belonging to the case and the quintain. Stake (2006) opines that the interrelationships among the research questions, themes and findings are explained and interpreted for consolidation and extension of understanding of the phenomenon in qualitative research.

The rigorous literature review available in my study period has sparked curiosity to carry out this research on myself. This review literature brought me some insights in relation to opportunity and challenges on the practices of ICT integrated pedagogy in higher education mathematics classes. While reviewing the related literature in my access, some questions raised in my mind; does mathematics teachers of TU practices ICT integrated pedagogy in their classes properly? If yes, then, how are they practices and what are their lived experiences of it and what are the perceptions of students about their practices?

The overarching question consisted of three major issues related to my research objectives; lived experiences of teachers on the practices of ICT integrated pedagogy, perceptions of students towards their teachers' practices and opportunity and challenges to integrate ICTIP. Thus, the overarching question was categorized into five sub-questions: How do students of bachelors and masters level perceive ICT integrated pedagogy in learning mathematics according to their interest and availability of ICT tools? Does the perception of students towards the implementation of ICT integrated pedagogy differ significantly as their institution and Gender type? Do the perceptions of students correlated by their discipline about the practices of ICT integrate pedagogy? How do teachers experience of ICT integrated pedagogy while

teaching mathematics in higher education mathematics classroom with a special focus on equity and transformation of learning? What are the opportunities and challenges to integrate ICT in pedagogical practices? These sub-questions were further broken into some probing questions to get the required information from the participants through semi-structured interviews, FGD, class observation, and survey questionnaires. So, the research questions of the study are as following:

1. How do students perceive the ICT integrated pedagogy in learning mathematics according to their interest and availability of ICT tools?
2. In what ways do the perception of students towards the implementation of ICT integrated pedagogy differ as their institution, level, location, and gender type?
3. The extent to which do the perceptions of students correlated about ICT integrated pedagogical practices?
4. To what extent does the general practice and input of ICT affect the output of ICT integrated pedagogical practices?
5. How do mathematics teachers experience ICT integrated pedagogy in higher education mathematics classroom?
6. What are the opportunities and challenges to integrate ICT in pedagogical practices in higher education mathematics classroom?

Significance of the Study

In higher education system of Nepal, we, teachers are committed to improve the teaching learning processes so that students benefit maximally in terms of input; knowledge, skills and attitudes. The rationale of this research is to find out the real practices of ICT integrated pedagogy as the best teaching approach in learning mathematics. The best practices of ICT integrated pedagogy is likely to be beneficial for a number of reasons; learning and assessment, collaboration and co-operations

between students and teachers, progress of students achievement, content coverage, equity management, pedagogical shifting and knowledge integrated across diverse disciplines. As a new pedagogical approach, ICT integrated pedagogy has been introduced as an emerging and best teaching technique. Hence, this research aims to contribute to address the equity issue by establishing ICT integrated pedagogy as the means of pedagogical transformation. Further exploration has also been made in relation of the opportunity and challenges in implementation of ICTIP and its impact on mathematics classes.

We can justify the significance of any study on various bases. This study is significant because ICT integrated instruction has massively increased in the past few years (Chang, 2012). In these regards, the practices of ICT integrated pedagogy helps to transformed the teaching-learning modality so that the face-to-face learning were transformed into blended learning or online learning through technology based resources and systems (Saglam & Sert, 2012 as cited in Singh, 2021). This paradigm shift requires educational institutions to train learners in such a way that helps them develop the 21st century skills: creativity, cooperation and collaboration. Furthermore, teachers need to be updated to facilitate learners as per the changing paradigm. This shows that the technology integrated pedagogy has greatly influenced teachers' perceptions and their preparation for teaching. In their study, Baek, Jung and Kim (2008) explored the factors that influence decision power of teachers in the practices of technology in their classroom based on the experiences of ICT integration. Thus, it is important to explore experiences of teachers in the integration of ICT into their pedagogical practices.

This study is highly significant because it explored and analyzed how mathematics teachers of constituent campuses of TU integrated ICT into their

pedagogical practices and what lived experiences they had. Moreover, as this study has also explored the perceptions of students towards the practices of ICTIP by their teachers in higher mathematics classroom from the research participants' perspectives, it essentially provides the scenario of the ground reality. My personal experience also reveals that the ICT integrated pedagogical practices in higher education mathematics is an under-researched area in the context of Nepal and that there is limited literatures in this area. The study is also highly worthy and necessary because ICT integrated pedagogical practices on mathematics in the context of Nepal is in the initial stage. In this sense, the research findings would be addition to the limited literature available including lived experiences of teachers and perceptions of students towards ICT- integrated pedagogy in higher education mathematics classes of Nepal.

The outcomes of this research are equally useful to the teachers and students utilizing the ICT tools and ICT integrated pedagogy of an institution or the nation. The research reflects the real practices of ICT integrated pedagogy in higher mathematics classes as well as the perception of students and experiences of teachers. Thus, the study is significant to all the related stakeholders of education, i.e. students, teachers, textbook writers, course designers, reference material producers, researchers, policymakers, in particular, and all other interested institutions and individuals in general.

Delimitation of the Study

This study was confined to mathematics students and their teachers from bachelor and master level enrolled in 12 constituent campuses of Tribhuvan University, Nepal where the ICT integrated pedagogy was applied in teaching mathematics. The study has the following delimitations:

- From the theoretical point of view, it was delimited to the social constructivist theory, and the theory of connectivism.
- This study was delimited to the ICT integrated pedagogy used by the mathematics teachers in their bachelors and masters level classroom teaching.
- The study explored only the perceptions of bachelor and master's level students towards the practices of ICT integrated pedagogy by their teachers.
- This study was delimited to the practice of ICT by the teachers and students like mathematical software: GeoGebra, Mathematica, MatLab, Mapple, SPSS, Excel, graphic design, New learning techniques: like e-learning, o-learning, v-learning, blended learning, hybrid learning, M-learning, ICT platforms like; e-mail, messenger, WhatsApp, Zoom, Teams, Viber, Moodle and ICT tools like; Laptop, computer, power point projector, internet, smart board, graphic computer.

Operational Definition of Key Terms

The key terms I have used in this study have been defined as follows:

Information and communication Technology (ICT). In my research, ICT refers the technological tools used to store, retrieve, manipulate, create, transmit, and process the information or receive such type of informations electronically in the digital form (UNESCO, 2010). I include new or old digital device as ICT tools that are used in pedagogical process for the construction and delivery mathematical knowledge in this study.

ICT integrated pedagogy. In this study, ICT integrated Pedagogy is a broader concept of teaching and learning activities including ICT tools. Therefore, ICT integrated Pedagogy is defined as the teaching techniques used by teachers using different digital tools.

Technological Pedagogical Content Knowledge (TPCK). In my study TPCK refers the integrated knowledge of teachers on three components; Technology, Pedagogy, and Content knowledge which is considered as a phenomenon of technology integration in pedagogical process.

Students' Perceptions. The students' perception in this study refers to the feeling of Bachelors and masters level students of constituent campuses of TU towards the practice of ICT tools and techniques by the teachers in their mathematics class.

Teachers' Experiences. The teachers' experiences in this study refer to the lived experiences of mathematics teachers to implement ICT integrated pedagogy in higher education mathematics classes.

Higher Education Mathematics Classroom. In this study, the bachelor and master level classes specialization in mathematics in different faculties of Tribhuvan University in academic year 2077/2078 were considered as higher education mathematics classroom.

Chapter Two

Review of Related Literature

The process of locating, obtaining, reading and evaluating the research in the related area of mathematics education is the literature review. It helps and gives the guidance to researcher for the future study. The review literature critically summaries the current knowledge in the area under investigation, identifying any strengths and weaknesses in previous work. Reviewing the literature is a continuous process which begins before identifying a research problem and continues until the report is finished. Literature review is also the description and critical analysis of works digital, and both current and seminal that relate to your research question and topic (Daymon & Holloway, 2005). In this research, here, I present the reviews of thematic, theoretical and empirical literature under different themes, sub-themes, the gap in literature, and conceptual framework of the proposed study entitled Teachers' Experiences and Students' Perceptions of ICT Integrated Pedagogical Practices in Higher Education Mathematics.

Theoretical Review

The main concern in literature review is to explore the globally available related literature that helped me to develop the conceptual understanding of this study. The review of related literatures provided me the knowledge of the systems of concepts, belief on that concept, researcher's expectations, and theories that support and inform the whole research process (Miles & Huberman, 1994). Moreover, a critical review of the available thematic, theoretical and empirical studies has been provided in this chapter. It has been divided into two essential sections; theoretical and empirical literature review. The section on theoretical review consists of the theoretical bases for pedagogical process, constructivist theory of teaching- learning

process and connectivism theory, the relationship between these theories with ICT, and application of theoretical perspectives in the research. Likewise, the section of the empirical review of related literature includes several categorizes; the integration of technology into pedagogical practices, teachers' experiences, their belief on technology, the attitude on the practice of ICT, professional digital training of teacher, impact of technology integrated instruction on students' achievement, the effectiveness of ICT integrated pedagogy in the educational system and challenges to ICT integrated instruction.

To link the theoretical perspectives on my study, I selected social constructivism theory and theory of connectivism relevant as they promote technology-integrated pedagogical practices (Keengwe & Onchwari, 2011). These theories believe that the learners are at the center of the learning process and teacher empowers them for decision-making on the construction of knowledge and its application (Merriam & Bierema, 2014). Likewise, TPACK model provides a framework for the integration of technology into pedagogical practices to deliver mathematical contents (Mishra & Kohler, 2006). This model guides teachers to integrate ICT into their pedagogical practices on higher education mathematics classes.

Student's Mathematics Learning Style

In this study, the theoretical knowledge from three interrelated theories; behaviourism, constructivism and connectivism helped to perceive the process of knowledge construction in relation to the phenomena of ICT-integrated pedagogy. The behaviourist theory establishes thought concerning knowledge. Skinner (1974) focuses on the issues that learning is external, objective, and developed through the personal experiences of the learner, establishing that the process of learning is stimuli-

responses, repetition and reinforcement. So, behaviour of learners in my research is a prime source of knowledge in behaviourist school of thought. The process of learning within this theory is mostly based on 'drill and practice'. Skinner's (1974) theory on conditioning and Gagne's (1985) theory on learning hierarchies are very influential on Mathematics teaching. Since knowledge is developed with building blocks; they are connected and should be grounded on building new mathematical contents. In addition, behaviourist theory also explains that knowledge is absolute, and argues for a programmed instruction approach. It does not care about the cognitive difference of learners for learning preferences and styles.

The theory of Cognitivism was popular during 1970s with Ausubel, Bruner, and followers. This theory reveals that learning is connected to previously relevant knowledge which already exists in learners' cognitive structure. Cognitivism theory states that learning is held from the cognitive insight of learner. The interaction between new and prior knowledge involves a change in learners' cognitive structure and is credited to new learning. According to Cognitivism, the prime source of knowledge is mental power. This theory believes that learners are self-responsible and dedicated to their learning. Therefore, learners need to clarify what they already know as secure concepts and in what way they connect to the learned concepts to new content. In this regard, Bruner (1990) argued that learning is a negotiation of experience and thinking.

Constructivism is a learning theory that believes learning is based on action. This theory was conceptualized by Piaget (1954) and Vygotsky (1978). This theory argues that the process of learning is active and generated from interaction between people's actions, experiences, and subjective states of mind (Stoilescu, 2016). This theory believes that learning is internal and constructed so that the action is a prime

source of acquiring knowledge. Action, reflection and socialization are key elements for learning in this theory.

The theory of Constructivism recognizes learning in more personalized and interactive way. This theory believes learners build mental representations by engaging in appropriate and active cognitive process of learning. It is persuasive to view constructivism as a means of instruction in which learners must be behaviorally active during the process of learning. In this regard, Piaget said learners can rearrange learning objects to reflect on their operations with different objects (Piaget, 1954). According to Piaget, mathematical knowledge is derived through assimilation, accommodation, schema and reflections. Likewise, Vygotsky's social constructivism states, that there is interaction between the learner and others; others can come in many forms (Vygotsky, 1978). This theory believes new information is linked to prior knowledge and learners construct knowledge based on personal experiences from mediators, parents, instructors, peers, digital tools and objects.

The theory of cognitivism, behaviourism and constructivism are the three grand learning theories that mainly used in the creation of appropriate pedagogical environments. These theories, however, were developed in a time when there was no much impact of technology in to pedagogical process (Siemens, 2005). Over the last three decades, technology brings changes in our living style, our communication process and our learning strategies. These theories also helps to describe learning principles and process that reflact the underlying social environments.

Connectivism is considered as a learning theory of the digital era (Siemens, 2005). It is a successor to behaviourism, cognitivism, and constructivism (Iadis, 2012) based on technology and network collaboration. Siemens believes that knowledge continues to grow and develop in connection with technology. Therefore, the ability

to see connections between ideas, and concepts linking to sources is the major concern to meet the given requirements. This shows connectivism as a combined view of constructivism and technology-based pedagogy as a means of diversity management.

Learning Theories for the Digital Era

The theory of Constructivism and Connectivism are the theories mentioned here, the learning theories of the modern society. The first theory I reviewed and used in my research is Constructivism. It is a theory of knowledge (Epistemology) that claim human generate their knowledge from the integration of their experiences and ideas. The constructivism theory believe that knowledge is constructed from the active participation of learners and its application has highlighted on process, collaborated learning and teaching for understanding (Crotty, 2012). The constructivism learning theory is based on a relativist ontology and subjectivist epistemology. Likewise, in constructivism theory, the actual meaning of knowledge is internally constructed in the mind (Scotland, 2012). This school of thought is characterized by the instruction process that states; that instruction is a process of supporting knowledge construction rather than communicating knowledge. The role of the teacher in this theory is a guide, rather than an expert transferring knowledge to novices. It believes learning activities are authentic and centre on learners' skills that fails to predict what they are experiencing. Teachers must encourage their students to reflect on experiences, seek alternative viewpoints, and test the viability of ideas. The constructivism theory believe on the learning principles that emphasize active participation of learner, engaged and interactive learning, scaffolding the students' learning and connecting with peers for learning through social interaction. This principle provides me with a wealth of information to understand how my participant

teachers use pedagogical strategies using ICT in the classroom. The social constructivist lens believes that teachers can build dynamic and engaged learning environments where students actively participate in knowledge construction through social interactions and collaborative efforts by incorporating ICT into mathematics instruction. Through the development of higher-order thinking abilities and a deeper comprehension of mathematical topics, this method equips students to effectively address issues in the real world.

I understand that to use the above pedagogical principles derived by Vygotsky into classroom instruction, the role of teachers' needs to change as a facilitator, guide, and mentor. Concerning in this study, I applied the theory of constructivism in three ways: the first one is the knowledge is constructed actively and its application has emphasis on process of concept formation, learning with collaboration and teaching for understanding. So that various ideas of students can be managed by encouraging them to reflect on experiences, seek alternative viewpoints, and test the viability of ideas. The second is the role of the teacher is a guide, rather than an expert transferring knowledge to novices. And another is to see whether the teachers encourage students to reflect on experiences, seek alternative viewpoints, and test the viability of ideas. Concerning my study, this means that by using ICT integrated pedagogy into their classes; they can provide clear concepts of mathematics with visualization.

Theory of Connectivism

The Connectivism is another theory applied in this research. Connectivism proposed specific technological opportunities for the students to be involved actively in the development of new knowledge. Siemens (2005) planned connectivism as an alternative learning technique that proposed learners attempt to foster understanding

of learners by developing connections between specialized communities (Duke, Harper & Johnoton, 2006). Connectivism concerns how a learners develop knowledge and perception through the addition of a personal network (Siemens, 2005).

Connectivism addresses the challenges of knowledge management activities faced by many institutions. The knowledge that resides in a database needs to be connected with the right people in the right context in order to be classified as learning. The starting point of connectivism is the activity of each individual in the learning process. The new knowledge is develop through a network, that helps the organizations and institutions to provide individual learning. This cycle of knowledge development in connectivism allows learners to remain current in their field through the connections they have formed and this understanding will be a key knowledge resource for understanding the process of learning.

Connectivism is a learning theory which is also taken as a basis for developing the concept of ICTIP. It argues that cognitive tasks between people and technology occur in networks which are connections among individuals, groups, systems, fields, ideas and communities. In Connectivism theory, learning occurs when knowledge is actuated through the process of learning connecting to the learning community.

Connectivism learning theory and connective knowledge as ways to understand and explore learning in the digital age are timely and particularly useful, both in what they offer and what they question (Sitol, Sopeerak & Sompang, 2013).

Connectivism includes several approaches and strategies to connect pedagogy with technology. In this process, connectivism taxonomy supports the finding of how learners encounter and explore learning in a natural learning community of networked mode (Siemens, 2006). He proposed some steps like; awareness and receptivity, contribution and involvement, connection forming, recognition of patterns, meaning-

making and praxis in his taxonomy. This taxonomy is very useful for the development of mathematical concepts through the activities of groups and interactions which are possible through ICT-integrated pedagogy in classes. The connectivism theories point-out the ways to connect between the concept of mathematics and digital technology through networking and nodes.

Connectivism is considered as the learning theory of the digital era (Siemens, 2005). In connectivism, learning has occurred when knowledge is actuated during networking by the process of a learner connecting to and providing information to a learning community. In these regards, Siemens (2005) states, “A learning community is the clustering of similar areas of interest that allows for interaction, sharing, dialoguing, and thinking learners together.” (p. 125). So, in the connectivist model, the learning community is described as a node, which is considered a part of a larger network. In a network, nodes arise out of the connection points. The network is comprised of two or more nodes linked to share resources for learners as described above. Nodes may vary by size and strength, depending on the concentration of information and the number of individuals who are navigating through a particular node (Siemens, 2008).

According to connectivism, knowledge can be stored in a variety of digital formats and distributed across an information network. Knowledge development and learning are said to “rest in diversity of opinions” (Siemens, 2008, p. 349). Learning is disclosed through the use of both affective and cognitive domains such that emotions and cognition both contribute to the learning process side by side. If information is continuously changing and its accuracy may change over time then a discovery of new relations in mathematics is possible. This means, one understands of a subject, one’s ability to learn about the subject in question will also change over time. As

connectivism states, two important skills contribute to learning is the ability to filter extraneous information and the ability to seek out current information. It reveals that “the capacity to know is more critical than what is actually known” (Siemens, 2008). According to this theory, the ability to acquire for making decisions based on information is integral to the learning process. People believe that, through multiple knowledge domains, learners may transverse networks. In this regard, Siemens asserts “The ability to see connections between fields, ideas, and concepts is a core skill” (Siemens, 2008).

Connectivism proposed a model of learning that acknowledges the shift in pedagogy through technology in the society where learning is not only an internal and individualistic activity (Siemens, 2005). When new tools are utilized, how people work and function is altered. In this situation, the field of education has been recognized the new trends of learning and advanced society. For this, Connectivism provides insight into learning skills and tasks needed for learners to flourish in a digital era. Overall, connectivism is the learning theory that connects technology with pedagogy through networking to facilitate learning process through networking.

The principle of connectivism provides the researchers with knowledge and perspectives to understand how learner can develop connections between fields, ideas, with concepts. In modern pedagogical process, learners have to recognize the impact of new learning tools and the changing environment through innovative ideas. In this regard, Connectivism (Siemens, 2005) provides insight for new learning skills and action oriented learners to do well in the technological world. Integrating ICT-based pedagogy is one of the prominent teaching techniques that helps to connect technology to the mathematics contents through networking. The connectivism helps to integrate learning and knowledge rests in diversity of opinions. It also believe that

the learning is a process that holds with the connection of specialized nodes or information sources.

The major principle of connectivism theory reveals that learning may reside in non-human appliances and it helps to increase the capacity of learner more than that the learner known currently. For this, to develop connections between technology and content is needed to facilitate continual learning. The focus on the ability to see connections between fields, ideas, and concepts is a core skill of Connectivism. Accurate, up-to-date knowledge is the main intent of all connectivist learning activities. According to this theory, decision-making itself is a learning process and it helps the learner be active and self-motivated.

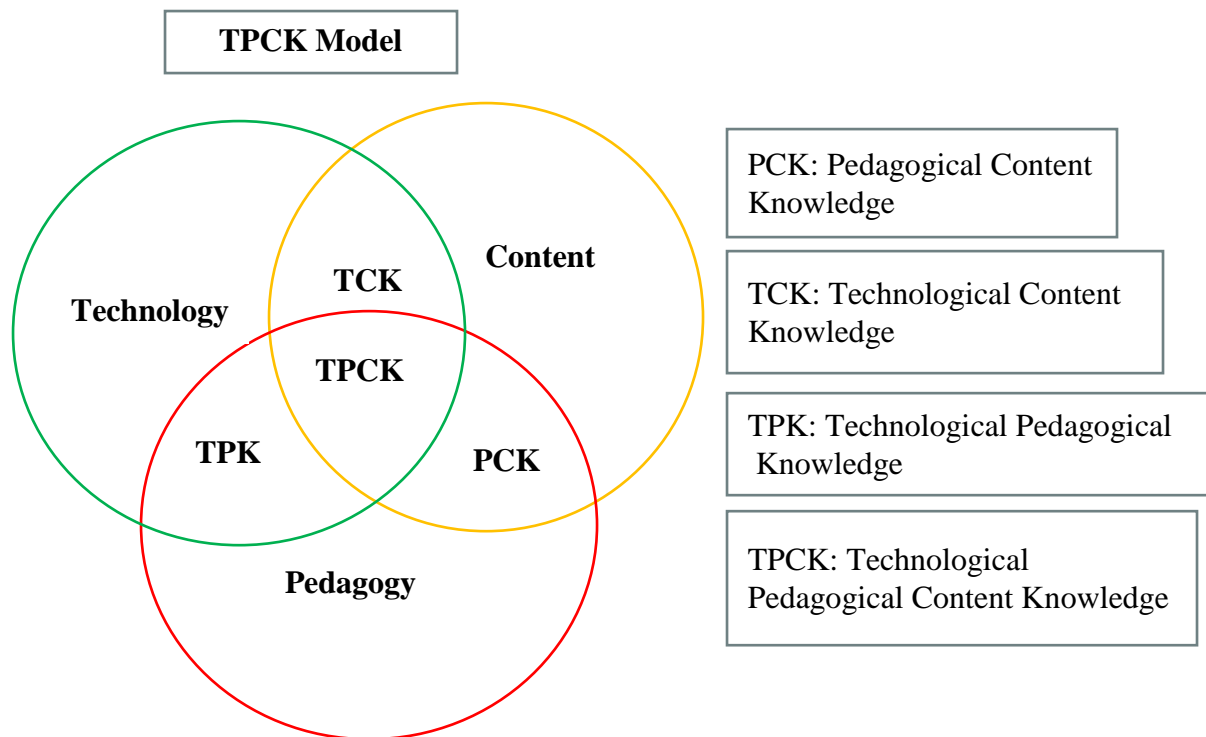
Connectivism theory can address the challenges that many institutions face in the process of knowledge management activities (Siemens, 2005). In order to classify learning, knowledge provided by the institutions needs to be connected with appropriate person in the institution. But, behaviourism, cognitivism, and constructivism do not attempt to address the challenges of organizational knowledge and transmission. In these regards, Connectivism presents a model of learning that acknowledges the paradigm shifts in a learning community.

In my research, there are two applications of Connectivism: one of them is connectivism as successor to behaviorism, cognitivism, and constructivism and a combined view of constructivism and technology-based pedagogy as a means of students' empowerment. So, a teacher empowers learner and facilitate them to learn abstract concepts of mathematics. The second one is connecting technology as a means of pedagogy with mathematical contents through networking with specialized nodes or information sources.

TPCK Model

TPCK model is the progressive model of 21st century which provided insights in my research to see how technology, pedagogy and content knowledge are interrelated concerning mathematics. Mathematics teachers in this 21st century need to use digital technology for effective teaching in their profession. The teachers in this era may be either digital immigrants or natives because they need to be knowledgeable on educational technology according to the new learning culture and needs of students. Since, in my experience student's learning culture in the present context is technology-friendly and self-regulated; they generally prefer to act together with digital tools/software. Therefore, every teacher today needs to use technological knowledge (TK) to demonstrate content knowledge (CK), with concepts, skills, and rigours with better pedagogical knowledge (PK) and develop a relationship between TK, CK and PK. Hence, the motto of a successful teacher must be utilizing TPCK model in their teaching profession (Mishra & Koehler, 2006). In relation to my study, I believe that twenty-first-century teacher's quality shall associate with the competencies to handle the learning culture of the new generation, to administer pedagogy with digital tools and develop students student-centred and interactive learning culture. So, this study aims to explore the role of technology-based pedagogy to helping students in learning higher mathematics content effectively.

In this concern, Connectivism (Siemens, 2005) and TPACK (Mishra & Koehler, 2006) models support an additional teacher's professional competency. The following model shows the relationship between TK, PK and CK.

Figure 1. TPCCK Model

The overlapping of three circles (as in the figure above) with three domains of knowledge; technology, pedagogy, and contents emerged four different types of interrelated knowledge; PCK, TPK, TCK, and TPCCK. The overlapping of all above mentioned three technology, pedagogy and content circles together is known as TPCCK and has four foremost components which can be described as follows:

Pedagogical Content Knowledge (PCK). The combination of two domains of knowledge: pedagogy and content is jointly called Pedagogical Content Knowledge (PCK). It comprises the knowledge of what types of teaching technique would be appropriate for the given contents and how can we develop appropriate teaching technique to deliver the specific content. Based on Sulman's notion, Mishra and Koehler (2006) define PCK as a teaching approaches fit the content and likewise, knowing how the specified content can be present for better teaching. The PCK helps to select appropriate pedagogical approach to deliver mathematical contents to the learner effectively.

Technological Content Knowledge (TCK). Technological Content Knowledge (TCK) is a combination of two knowledge domains: technology and content. It suggests the teachers to select appropriate technologies for content delivery. So, TCK can be defined as “the way in which the technology and content are reciprocally related” (Mishra & Koehler, 2006, p. 1028). Besides, it suggest that TCK enables teachers to select appropriate content delivery mode of instruction selecting best technological tools.

Technological Pedagogical Knowledge (TPK). The combination of two knowledge domains; technology and pedagogy is (TPK). It required to combine technologies in pedagogical process to deliver specific content. Mishra and Koehler (2006) define TPK as the knowledge of “the existence, components and capabilities of various technologies as they are used in teaching and learning settings, and knowing how teaching might change as the result of using particular technologies”. Thus, TPK it suggest teachers to know which particular technology is effective for their teaching activities. The major challenges for teachers is to select appropriate technology in their pedagogical practices in the context mathematics.

Technological Pedagogical Content Knowledge (TPCK). The final construct developed by Mishra and Koehler (2006) is Technological Pedagogical Content Knowledge (TPCK). It is the product of the combinations of three domains of knowledge: technology, pedagogy and content together that develop a special type of knowledge to the teachers. Thus, as suggested by Voogt et al. (2012), a teacher need such domains to integrate technology appropriately into their teaching profession.

The rapid development of technology is challenging for the professional teachers because it is not fixed over time like earlier technology. Mishra and Koehler (2013) shows that some teachers have unwilling to adapt and apply newly developed

technologies due to a fear of change, and inadequate time and skill eventhough, they need to apply recent technological knowledge and skills to integrate ICT into their pedagogical practices. In this way, TPACK is practiced massively over all developed countries as the basis of teaching contents effectively with technology. It requires a good interlinking between three components of knowledge: technology, pedagogy and content. In my study, I have looked at whether the contents of mathematics were taught using technology or not and to find the role of technology to learn mathematics effectively.

Augmented Reality in Education

The concept of augmented reality (AR) in education suggests that by overlaying digital information into the real world, learners can engage in a more intensive, interactive, and contextual learning experiences (Kipper & Rampolla, 2012). It leads learner to deeper understanding and updated knowledge, particularly in the process of learning complex or abstract concepts of mathematics. Beside these, AR permits learner to explore and employ information actively within their physical environment, fostering a meaningful learning process.

The AR technology in education suggests that by overlaying digital information into the real world, learners can engage in a more immersive, interactive, and contextual learning experiences. It leads learner to deeper understanding and updated knowledge, particularly in the process of learning complex or abstract concepts of mathematics. Beside these, AR permits learner to explore and employ information actively within their physical environment, fostering a meaningful learning process. In the learning process, the augmented reality provides equal opportunity for each individual that promotes equity in learning. It allows for personal learning and can easily be understood the mathematical concepts using different

forms of content (e.g. pictures, verbal, tactile) to show the necessary information so that the learning environment is isolated from dangerous. AR aims at simplifying the user's life by bringing virtual information not only to his immediate surroundings, but also to any indirect view of the real-world environment (Carmigniani & Furth, 2011). AR has been used in various ways since 1950s that began more popular after the start of internet, through the diversity of mobile devices and with wearable technologies becoming widespread. AR is a variation of a virtual reality (VR) as it is more commonly called (Kipper & Rampolla, 2012). The benefits of using augmented reality in educational process are presented below:

Improved comprehension. The AR can facilitate better understanding of complex topics by visualizing abstract concepts of mathematics in a tangible way.

Enhanced engagement. The interactive nature of AR can increase interest of students and motivation in learning process.

Personalized learning. The AR can be tailored to individual need of students by providing customized information and learning pathways.

Accessibility. The AR can provide visual materials to support different learning styles and cater to students with learning disabilities.

There are mostly two types of augmented reality i.e. marker-based and marker-less in educational process. The marker-less AR includes projection based AR, outlining AR, superimposition AR and location- based AR. The marker-less augmented reality interfaces are more flexible, accurate and professional. The use of marker less AR promotes flexible learning and beneficial for the job holder students . It foster meaningful learning by providing equal opportunity for each students. The application of this theory in my research is to see whether or not the use of technology based teaching promotes equity in the class or not.

Technology Acceptance Model (TAM)

This model was developed by F. D. Davis in 1989 that forecasts the user's willingness or attitudes towards the use of technology (Davis, 1989). The TAM model suggests that when new ICT tools is presented to students and teachers, their decisions about their practices is influenced by two factors: (i) perceived usefulness, and (ii) perceived ease of use. The perceived usefulness refers to the belief of person that the use of the technology would be free of effort, and perceived ease of use refers to the belief of users that the technology would enhance job performance. In relation my study, I have looked at whether the students and teachers accept technology or not in their pedagogical process.

ICT Perspectives and Use in Practice: Empirical Review

This section presents some ICT related empirical literature in terms of gaining insights related to my study along with the implication of knowledge from the literature and intends to find the research gap. It informs me about research works carried out in my research area. It brings more clarity and focuses on research problems, generates ideas to set methodology, broadens knowledge in the research area and contextualizes the findings (Kumar, 2009). In doing so, some of the research works carried out nationally and internationally related to ICT-integrated pedagogy in mathematics classes were reviewed and presented here.

There are tangible benefits to the students from the exploration of ICT in education. Stewart and Taylor (2007), for example, in their work on investing in ICTs in educational institutions in developing countries examined the impact of ICT projects in educational institutions in Kenya. The research was conducted on teaching staff, current students and former students together with parents of current students using interviews. In this research, they established the current policies concerning ICT

in awareness, access and usage of technology in education on Kenya. The findings of the research suggests different benefits to students from exposure to ICT, and it concern about how students with different capacity, nationality, socio-economic and linguistic characteristics experience such benefits differently. Although the findings of this research suggests that exposure to computers in educational institutions influenced the career choices of former students, this knowledge is insufficient to explain student's learning experiences based on gender, ethnicity and culture.

In the context of Nepalese school education, the community school teachers exhibited better job satisfaction, media utilization, and more positive towards ICTs. Newa (2007) for example, in his work aimed to compare secondary school teachers attitudes towards ICT of community and institutional backgrounds and examine their interaction effect on variables such as teacher effectiveness, job satisfaction, media utilization, attitudes towards media. Secondly, it sought to compare the secondary school teachers from three main academic streams viz. language, science/math, and social studies concerning the aforementioned variables. Community school teachers were more satisfied with their job than that of institutional schools (Newa, 2007). Effective teachers exhibited better job satisfaction, media utilization, and more positive towards ICTs. More than 50% of the teachers revealed that media can promote interaction which helps students for better comprehension. Institutional school teachers used more media than community school teachers. Most of the teachers didn't use electronic media such as slides, films, computers, Internet etc. Majority of the teachers, however, used non-projected media such as journals, magazines, charts, graphics, drawings, and documents. The teachers of both types of schools were positive about the role of the ICTs for quality learning. More than 50% of the teachers strongly agreed about the role of ICT-based education for enhancing

student-centered teaching, interactive environment, collaborative learning, and self-learning.

There is a growing importance of considering factors such as school type, academic stream, and teacher effectiveness when examining attitudes towards ICT and its impact on teaching and learning (Newa, 2007). The result suggests that there is a need for further support and training to enhance teacher's utilization of ICT and media resources, particularly in the context of community schools. Additionally, more effort should be made to promote the interaction of ICT in all academic streams to ensure a more balanced and comprehensive approach to technology integration in education.

Likewise, there are several barriers to successful ICT integration viz. insufficient training for trainees, lack of technical support, absence of training centres, and lack of associated tools. Pouzevara and Parajuli (2007), in a case study, examined the effectiveness of ICT tools in bringing better learning outcomes and identifying the barriers and drivers of successful ICT integration. The study focused on "innovative ICT in education and its potential for reducing poverty in Asia and the Pacific Region" project, implemented by the Research Triangle Institute (RTI) in Nepal, Bangladesh, Samoa, and Mongolia. Overall, the study contributes to our understanding of the potential benefits and challenges of integrating ICT in the field of education, particularly in the context of reducing poverty in Asia and Pacific region. However, this study does not provide subject-specific examples of the use of ICT in pedagogical practices.

In the same way, the literature suggests that there is a need for an implementation program that involves both the government and private sector to further encourage and support the potential of ICTs in Nepal (Neupane, 2010). Based

on a study in Nepal, Neupane (2010) focused on the current state of ICT development in Nepal and emphasized the importance of maximizing the benefits of ICTs through collaborative efforts between different stakeholders. Similar to the previous studies, the research did not cover how teachers used ICT in teaching various subjects at the school level in Nepal.

The status of ICT education in Nepal is largely covered in other studies as well (e.g. Wagle and Jha, 2013; Acharya, 2013) and they provide knowledge regarding the ICT infrastructure and tools that has been used in Nepal. The literature suggests various challenges to overcome in order to implement ICT in teaching. Several ICT tools such as mobile phones, laptop, and multimedia projector; and the web tools like YouTube, Facebook, Wiki, Blog, and E-mail were found using in ELT (Acharya, 2013), but little evidence was observed regarding how mathematics teachers used ICT in everyday classroom in Nepal.

There are some works done in mathematics education outside Nepal (e.g. Stols (2012). In particular, there are studies that investigate the difference in the geometric cognitive growth of pre-service mathematics teachers through the use of technology in terms of the Van Hiele levels. The study suggests that the use of dynamic geometry software enhanced student teachers' geometric visualization, analysis and deduction, but it did not enhance their ability to informally justify their reasoning and understanding the formal aspects of deduction. Additionally, the use of Technological Pedagogical Contents Knowledge (TPACK) in pre-service secondary mathematics teachers has been another area of research outside Nepal (Mudzimiri, 2012). The finding of Mudzimiri's study reveals that the development of pre-service teachers' mathematics TPACK is complex due to factors such as the pre-service teachers' prior experiences with technology, their beliefs and their mathematical

background about the use of technology in mathematics instruction. Also, another cause for the complexity is the available model for mathematics teachers' TPACK was developed through observations of in-service mathematics teachers. Likewise, the TPACK self-efficacy shows a highly significant relationship with the planning and implementation of ICT-integrated pedagogy, but the GPA of students in educational technology and ICT-related courses was found to have a negatively significant relationship with their planning and implementation of ICT Integrated pedagogy (Mercado & Ibarra, 2019). This study further indicates that most of the respondents perceived themselves to be highly proficient in all domains of the TPACK framework. While this study is relevant to understand the use of TPACK in mathematics education, there is a knowledge gap considering the cases of mathematics education in Nepal.

There is a significant statistical effect of studying in an e-environment on the changes of intellectual thinking dispositions in all seven thinking dispositions (Bouhnik and Carmi, 2012). According to the dispositional theory of Perkins, Jay and Tishman (1993), these effects are evident in the pedagogical and technological elements of e-courses, in changing levels of positive power in all seven thinking dispositions. Additionally, students were positively influenced by using computer technology and felt that the use of computer technology was compatible with traditional lesson delivery (Colandrea, 2012). The perception of teachers about the diffusion of Computer-based technology in K–12 schools indicates that their leaders supported them in computer technology use in general and computer maintenance support in particular (Colandrea, 2012). The findings of the research indicated that teachers have higher job satisfaction when using computer technology in K-12 schools. The use of computer technology in lesson planning is positively affecting

students mathematics achievement (Colandrea, 2012). The findings of above studies concludes that teachers were satisfied with their jobs through using computer technology in lesson planning and use of technology based pedagogy in their mathematics classroom. Likewise, there is positive effect of interactive technology like TI Nspire calculators, TI-Navigator and clickers on algebra learning at school level (Camara, 2013). These interactive technologies and engage learners in classroom. But there is no significant effect for the Motivated Strategy for Learning Questionnaire (MSLQ) based on the use of technology, however, the use of technology with the State of Texas Assessment of Academic Readiness test (STAAR) shows a significant difference in test scores of experimental and control group students (Camara, 2013). These results support the use of additional technology that is needed in mathematics classrooms to support the use of the calculator.

The maximum number of students expressed that they experienced an increase in their math competency as a result of using the Nspire Navigator (Lucas, 2013). There is no significant evidence of wider community group identification by students, or the disposition to expand and transfer math problem-solving skills learned in the classroom into wider student communities of high school math learning spaces with interactive technology and transformative pedagogy(Lucas, 2013). The result of the study also concludes that to tease out this kind of wider community group identification, more directed questions should be asked. For increasing the achievement of students on mathematics, technology would be used in such a way that math activities must extend beyond the classroom and into students' communities. However, there is no statistically significant relationship between the degree of acceptance of new technologies and technology usage in mathematics instruction and

teachers' affective reactions to technology toward integrating computers and technology into math instruction (Aguirre, 2014).

There are some studies related to attitude of mathematics instructors towards E-learning outside Nepal (e.g., Alodail, 2016). This study conclude that there is significant difference between males' and females' attitudes toward the use of E-learning in the classroom and the female group had more positive attitudes than males. The result also showed four predictors; perceived computer, perceived computer attributes, competence in education, and perceived culture of using computers in education significantly predicted the attitude of students (Alodail, 2016). Additionally, the perception of teachers shows that the factors such as learning environment, change management, and student motivation influence technology integration in mathematics classroom (Ames, 2016). Though many influential factors emerged, they seems highly interrelated, the most common theme that emerged across all factors was that letting teachers show each other how to use technology to make life easier and improve learning for students may result in higher levels of technology integration (Ames, 2016) .

The review of the past studies also suggests that ICTs have capacity to make the world knowledge available overcoming the time and place barriers. ICT helps learners making easy access to information and learning materials which can enable the learners to be rich on resources, and which can make the modalities such as distance learning, online learning or life-long learning more effective. The use of technology shows positive impact on mathematics, making the classroom activities more engaged and interactive. However, these studies does not provide experiences of teachers towards the use of ICT in pedagogical practices in Nepal.

ICT as Pedagogical Practices: Enhancing Students' Achievements

There are some barriers such as professional support and access to hardware and software that largely diminished over the last twenty years due to an influx of money and strategies for enhancing technology in primary and secondary schools in the United States (Ruggiero & Mong, 2015). Due to such external barriers teachers fail to use technology in a way that matches their practised teaching style. Although, technology integration is enveloping in the classroom with the most often used technological tool identified as PowerPoint, teachers identified that training about technology is most effective when it is contextually based on their classroom activities (Ruggiero & Mong, 2015). The opinion of teachers also indicated that the other external barriers such as a lack of in-service training, a lack of available technology, and a restricted curriculum have negative impact on technology integration in mathematics classroom. Similarly, there was no statistically significant correlation between the degree of implementation of personalized learning and student achievement eventhough, 89% of educators agreed technology eased the implementation of personalized learning (Pillely, 2016). Using technology for teaching and accessing resources outside of the classroom is the most with frequent use for devices. The result also shows that there is no statistically significant difference between mean scale score gain on reading and math diagnostic assessments between groups (Pillely, 2016). The study also conclude that various degrees of personalized learning, even when disaggregated by schools with and without one-to-one technology implementation. In another study, Bluman (2012) concluded that there is no correlation between mean score gain on reading and math diagnostic assessments between two group of mathematics students at K-12. The study of Bluman (2012) also shows that there are multiple possibilities for the lack of

correlation, including the inability to correlate scores from a specific class of students to an individual teacher's responses.

Information-driven societies in the world today, are very complicated. It is therefore, the students of this twenty first century were powerful and self-directed 'navigators' on the information ocean (Trushell, Byrne & Hassen, 2013). In this concern, the study of about students' use of ICTs (i. e., purposes of using virtual learning environment (VLE), and Internet), and students' engagement on lecturer impressing strategy and cheating behavior such as plagiarism found that the younger students had greater tendency of being engaged in social internet activity such as maintaining blog, and leisure time activities like playing online games, and downloading film, and music (Trushell, Byrne & Hassen, 2013). This study also conclude that, students were engaged relatively less frequently in downloading educational materials such as lecture notes and recommended reading eventhough, there were strong positive correlations between frequency of e-mail correspondence by VLE and internet activities of looking for information about studies and looking for news and current affairs. Likewise, using information technology, we can help students by enhancing their ability concerning brains cognition capability like left and right oriented approach. This demanding world of productive demands, students' KSA (Knowledge, Skill and Ability) should be tapped properly to bring the innovative thought process out of their inner core through technology integrated instruction (Prasad, 2016). The result of Prasad (2016) also reveals that the learning orientation of students can be approached concerning ordering and perception. It may be the derived approaches of students also. The trenchancy of each individual is always proportional to the methodology through which knowledge gets digested (Prasad, 2016).

IT is a discipline that deals with Science, Technology, Engineering and Management in handling information and its applications related to social, economic and cultural matters. Currently, the dependency on internet technology and related gadgets to fulfil the basic needs of the routine life of the world's population is 90% (Patel & Patel, 2017). The study also conclude that ICT pedagogy makes the process of teaching-learning and evaluation more fascinating, easy to understand and all involved with a smoother application (Patel & Patel, 2017) . Using varieties of ICT tools, students from any corner of the world can share their knowledge and solve their difficult problems with other researchers. Learners of mathematics show that in many fields of study, ICT-based learning is useful to improve understanding of practical knowledge. In this context, a technological revolution is very important for all human development in this smart world, especially in the educational field.

In the context of Nepal, there are limited studies about the role if ICT to improve students achievement (e.g., Dhakal, 2019). This study conclude that Virtual Learning Environment in Mathematics (M-VLE) contributed to resourceful learning by anytime anywhere learning opportunities, 21st century learning skills (3Cs) and e-resources repository. M-VLE contributed to engaged learning through Emotional, Social and Cognitive presence, and interactive learning by human, machine and object levels of interaction (Dhakal, 2019). This study also conclude that the M-VLE helps for meaningful mathematics learning by Action, Process, Object and Schema levels of learning. Similarly, the major challenges of M-VLE intervention for end users were device constraints, internet connectivity, real-time support and feedback in teaching higher Mathematics courses with seven pedagogical principles with critical judgment of overall context (Dhakal, 2019). Additionally, if the teachers use collaborative activities through ICT tools, it helps students to increase exposure in their subject

area, sharing their ideas easily, and make them more creative and collaborative. However, another study reveals that students were not confident about using English language learning (ELL) -specific websites/software, there is teacher dominant learning approach, and the collaborative activities focused on the students' communicative skills rather than their higher-order thinking skills (Poudel, 2020). This study also conclude that ICTs used by the teachers keep themselves updated to prepare and present their lessons eventhough, they were not satisfied with the advantages of ICTs they could take, and less than a majority of the students found ICTs 'very useful' to use them 'usually' in their ELL activities due to the challenging factors such as inadequate ICT infrastructure, poor technological-pedagogical skills, negative attitude of parents, and rigid nature of the curriculum.

There is poor internet and compoter facility in most secondary schools which impeded technology-integrated instruction and they had a low investment in ICT infrastructure due to the high costs of computer hardware, software and other digital tools in Kenya (Bariu, 2020). The findings of the study reveals that many secondary schools of Kenya did not have proper ICT facilities to conduct teaching and learning activities. Likewise, a gap between the ICT policies in education and the execution of those policies in practice exists in Nepalese schools (Singh, 2021). This study further recommended all stakeholders and agencies of school education need to pay timely attention to updating the required infrastructures including professional capacity building of teachers for effective technology-mediated pedagogical practice(Singh, 2021). However, these studies does not provide policies and practices to integrate ICT in higher education mathematics classes of Nepal.

Challenges to ICT Integration in Teaching

Teaching is an art, logic and science which brings change in teaching and learning platform. The platform used in education along with “teacher, students, learning content, and physical classroom” are “internet, cloud space and digital tools”. Now a days, the teaching space is incorporating both physical and digital spaces. The common example is that YouTube, Facebook, Twitter, and Moodle and others are digital tools that are creating new learning opportunities as digital spaces in education (Kaplan & Haenlein, 2009).

There are several challenges to integrate ICT in educational system. Some researches carried out about the obstacles or challenges of integrating ICT in teaching have been reviewed below:

There are two types of obstacles to integrate ICT in pedagogical practices; the first type of obstacle belongs extrinsic to teachers and include a lack of computer hardware, inadequate time for instructional planning, and insufficient technical and administrative support. Likewise, the second-order obstacles as intrinsic to teachers that include teachers belief about their instruction with classroom setting, beliefs about technological tools, and unwillingness to change their dimention (Ertmer et al., 1999). The further study recognize three types obstacles; physical, educational and psychological. The first two obstacles are same as others including philosophical obstacles referred to the assumptions that governments and administrators held in terms of spending large amount of budget in to invest innovative tools (Yildiz, 2007).

Beside this, ICT integrated pedagogical practices in mathematics requires extra budget for planning, maintaining, support for upgrading, recrument of skilled manpower for professional development to encourage teachers for productive integration of ICT in pedagogical practices (Yildiz, 2007). In the context of Nepal,

there are challenges, like institutional, access, classroom, and instruction to integrate ICT on mathematics classroom due to contextual circumstances. Teachers were applying zoom, teams, google meet and other software apps for interactive purposes. They are facing problems in preparing teaching-learning materials, sharing them with the students, giving and checking assignments (Kandel & Kafle, 2021).

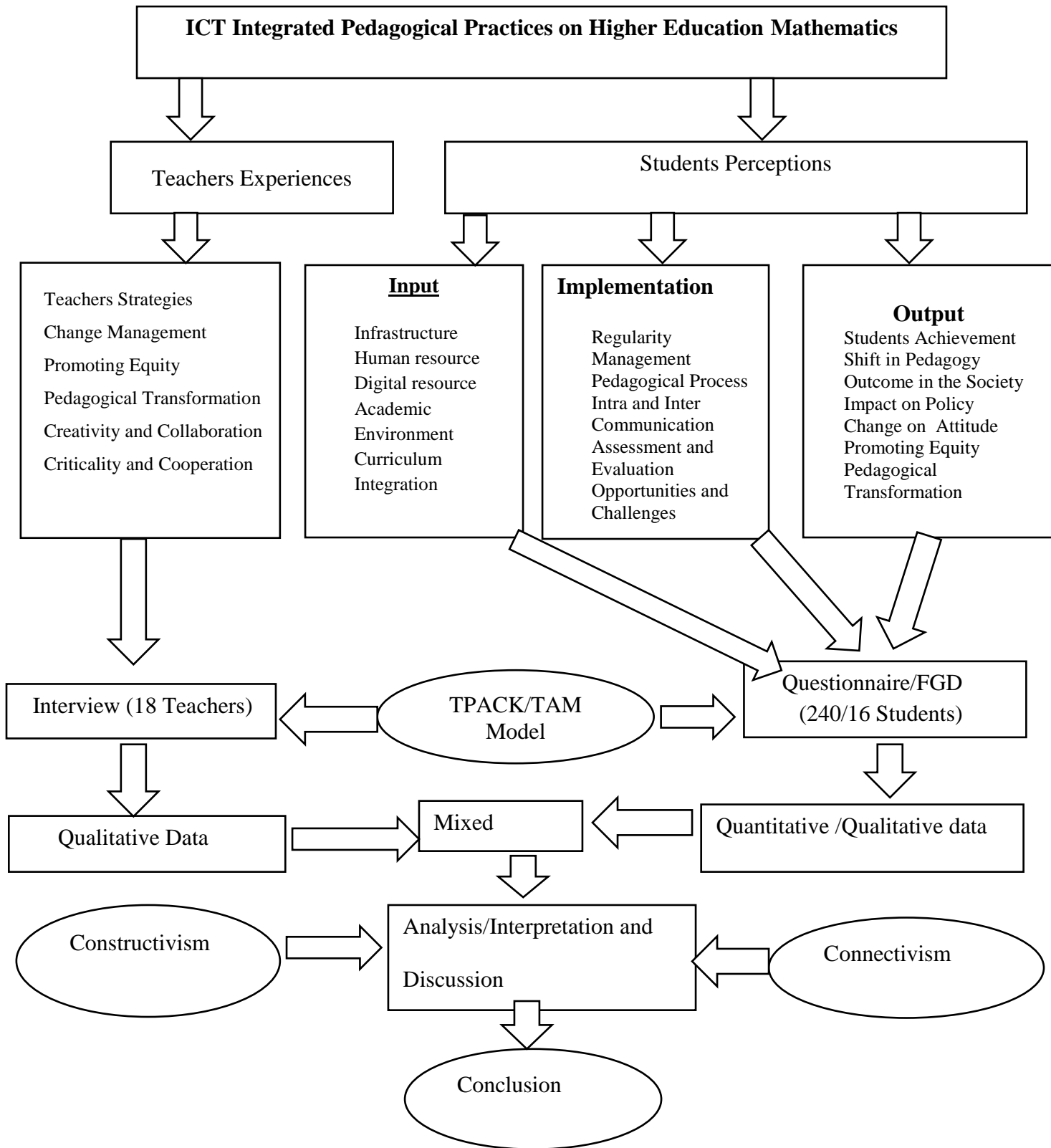
There is positive attitude of teachers towards the use of ICTs eventhough, the teacher face nsufficient class time, lack of ICT infrastructures, and inadequate training opportunities for their professional development (Thapaliya, 2014). This study also conclude that the widely used ICTs were audio tapes, mobile phones, television, radio, videotape, computers and email. This review makes it clear that the ICT development in Nepal is in its initial stage, it is just crawling on its knees. Some of the main problems of ICT integration are the lack of technological pedagogical skills of the teachers and the lack of ICT infrastructures. However, many commentators view that a thoughtful use of ICTs has significant potential in widening access to and improving quality of learning (Abbott , 2001). Additionally, there are six major arguments used to criticize the relevance of ICT and justified the role of ICTs in the achievement of students (Leech, 2008). The six different views are (i) the technological view that access and infrastructure are too undeveloped, (ii) the donor view- basic needs such as food and water must be the priority, not the ICT, (iii) the anthropological view- using ICT is so complicated for rural teachers and pupil, (iv) the standard view- use of technology is more costly for rural context, (v) the individual view- technological hardware should be lost, broken, or stolen, and (vi) the transmission view-ICT add nothing distinctive to effective teaching and learning (Leech, 2008).

The reviewed literature as mentioned above have some barriers or limitations to integrate ICT in pedagogical practices. These limitations or barrier includes internal and external factors such as inadequate time for learners and insufficient technical support, lack of ICT skills and confidence in teachers, rigid curriculum and traditional educational structure, insufficient incentive, demotivation from peers etc. Moreover, the literature review also presents the impact of ICT integrated pedagogy on students' achievement due to lack of leadership support, technical support and administrative support. Besides this, the review literature related to practices of ICT into pedagogical practices mention above brought me the knowledge that the findings of research report are highlyuseful in the context of Nepal. Additionally, it helped me to find the research gap and helped to get methodological clarity in my research area.

Conceptual Framework

The learning theories discussed above reveal that the field of instructional design need to recognize that learning is a human activity and is quite diverse in its manifestations from person to person even from day to day. The emphasis can then shift to developing pedagogical media that provide many alternative ways of teaching, which learners select as they engage in their educational experiences. In this context, the major concern in this study was to investigate whether the teachers able to create such a meaningful environment and students to learn according to their pace and capacities. The following picture presents the conceptual framework for the teachers' experiences and students' perceptions in ICT integrated pegagogical practices on higher education mathematics classes.

Figure 2. *Conceptual Framework*



This diagram/figure shows the procedural framework to find the perception of students and experiences of teachers towards the practice of ICT integrated pedagogy

in higher mathematics classrooms. The theory of constructivism and connectivism suggests some opportunity and strategies for effective mathematics teaching.

According to these theories, the teachers who taught mathematics need to focus on classroom culture and personal behavior of students such that it helps in pedagogical shifting through effective implementation of ICTIP. The students construct their knowledge through their active participation that's why the teacher plays the role of facilitator in their pedagogical process. For this, the mixed method approach is appropriate to find experiences of teachers and perceptions of students about the practices of ICT integrated pedagogy. The ICT integration contributes to pedagogical transformation as a best approach that helps students learn effectively.

Research Gap

From the above discussion of the related literature, a lot of studies have been carried out around the world on the use of ICT, its effectiveness and the role of ICT to increase students' achievement. Several investigations and reviews regarding the use of ICT in mathematics achievement have been conducted in various places like America, Africa, Canada, England etc. In the context of Nepal, as a new dimension, ICT-integrated pedagogy is introduced as an emerging and effective technique on different levels and disciplines of Tribhuvan University. A study conducted by Dhakal (2019) established ICT-integrated pedagogy as the best teaching method. He concluded that M-VLE contributed to meaningful Mathematics learning by Action, Process, Object and Schema levels of learning. Likewise the findings of the research conducted by Singh (2021) concluded that there exists a big gap between policies and practices of ICT tools in education and the execution of those policies in practice at Nepalese schools. All stakeholders and agencies of school education need to pay

timely attention to updating the required infrastructures including professional capacity building of teachers for effective technology-mediated pedagogical practice.

In Nepalese context, a research conducted by Poudel (2020) concluded that ICTs were used by the teachers to keep themselves updated and to prepare and present their lessons. Likewise, the collaborative activities used by teachers in their classes with ICT tools helps the students to increase the amount of exposure to English. In reviewing process, it is found that there are very few researches done to materialize to find the teachers' experiences and students' perceptions on technological practices. For the betterment of student's achievement by creating equitable environment in the classroom and to establish ICTIP as a major contributing factor for pedagogical transformation on higher mathematics classroom. In this context, I see that there is a space to do study to find the role of ICT integrated pedagogy for promoting equity and pedagogical transformation. However the issue of ICT integration is not much focused on the topic teachers' experiences and students' perceptions of ICT Integrated Pedagogical Practices in Higher Education Mathematics in Nepal. Therefore, I found a research gap on this issue and feel very crucial to conduct a study in this area to partially fill in the gap regarding ICT integrated pedagogical practices in higher education mathematics classes.

Chapter Three

Research Methodology

This chapter incorporates the methods and procedures for carrying out the research work. More briefly, it includes the research paradigm through which this research was guided; the selection of participants for the study; the methods for collecting and analyzing the data, and interpreting the results applied for this study. Finally, I described some procedures employed to fulfill the ethical requirements during the process of data collection in the field.

Research Paradigm

Any research process includes systematic inquiry of knowing or understanding the social phenomenon to provide insights into social action and social transformation (Mertens, 2010). The systematic research process concerned with the understanding of the research problem such that it informed the researcher about the reality (Cohen, Manion, & Morrison, 2007). This type of understanding and description of problem is a research paradigm, and it is composed of certain philosophical assumptions that guide and direct the thinking and action (Mertens, 2010). Defining research paradigm, Cohen, Manion, and Morrison (2018) opined that the research paradigm is a philosophical intent or motivation to undertake a study. Similarly, Denzin and Lincoln (2005) define the term paradigm as the theme that contains ontological, epistemological, and methodological premises of the researcher. Thus, the research paradigm is about its ontology, epistemology, and methodology in research activities. In this concern, Creswell (2014) stated the research paradigm is the philosophy of inquiry or worldview of the research. Therefore, the research paradigm is fundamental for any researcher to design research and produce knowledge from this study.

Philosophy gives ideas for me to choose an appropriate research methodology based on how I consider reality, and means of reality and adopt processes to acquire reality.

There are several worldviews (Research paradigms) in educational research. In several place in the literature, it is mentioned that the common paradigms in educational research are positivism, interpretivism, transformative theories and pragmatism (Creswell, 2014). In this study, I stand on the pragmatic paradigm. Creswell mentioned that it usually involves an action agenda for social change. In this study, I explore the realities of ICT integrated pedagogical practices in higher education mathematics classes and shows the contributions of ICTIP to maintain equity in the classes. Therefore, I inquire with the pragmatic paradigm because pragmatic paradigm-based research deals with the reality of the mathematics classes in a higher level. Creswell mentioned that this type of research activity is more problem-based and involves appropriate strategies to overcome existing problems (Creswell, 2014). So, I hope the experiences of teachers and the perception of students towards the implementation of ICT-integrated pedagogy helps to explore the real practices of ICTIP that helps for pedagogical transformation in learning mathematics effectively.

Ontological, Epistemological and Methodological Assumptions

Ontology is the branch of metaphysics that is concerned to identify the nature of reality (Creswell, 2014). The word ontology comes from the Greek; ‘ontos’ means ‘being’ and ‘logos’ means ‘study’ in combination, it is the study of ‘being or reality’. It is also concerning to address the question ‘what is the status and nature of reality’ (Guba & Lincoln, 1994). Thus, the status and nature of reality are assumed to be created based on the subjective experiences of researcher’s internal/external world. It is constructed in the minds of individuals (Guba & Lincoln, 1994) that is what an

individual perceives in the context and significantly varies from person to person and place to place. Ontology is a philosophical field related to the belief in the nature of being. It focuses on the logical types or categories of beings (Gray, 2014). Scholars (Creswell, 2014; Denzin & Lincoln, 2011; Gray, 2014) indicate that ontology is about “belief in reality”. There are subjective and objective realities in practice. Among them, subjective is a more personal construction whereas objective is something that already exists over there and there is no role of a person's subjectivity.

Epistemology is the branch of philosophy that concerns the study of knowledge. The word epistemology comes from the Greek, ‘episteme’ means ‘knowledge’ and ‘logos’ means study and as a whole it means ‘the study of knowledge’. The epistemology does not look for universality because it believes that the nature of reality is subjective and relative. Consequently, it believes in “multiple realities” about the phenomenon (Cohen et al., 2018; Creswell, 2018). Thus, epistemology is basically concerned with the relationship between knower and the known. Similarly, the relationship between the researchers and that being researched is described by epistemology (Creswell, 2014). Thus, epistemology is the philosophical field revolving around the process of knowledge to reach it. It is views on knowledge to deal with sources of knowledge. It studies how we know what is real knowledge. It is described in several works where epistemology is a perceived relationship with knowledge discovered (Creswell, 2014; Gray, 2014; Denzin & Lincoln, 2011). They mentioned that epistemology is about “what is the nature of the relationship between the knower (the researcher) and the known (the research).

Methodology is the science of exploring knowledge. It concerned about the research process which is primarily interconnected with the objectives of the research, learning theories and philosophical perspectives (Lincoln, Lynham & Guba, 2011). A

philosophical understanding is required to choose the research design regarding the methods to be used and methodology (Creswell, 2018). In addition, it is a special type of research strategy that shows the way in which research is conducted and select the methods to be used on the research process. Hence, the methodology is not only the specific methods to give attention in the nature and process to obtain the specific objectives of research. Similarly, it deals with how knowledge is discovered and analyzed. Therefore, methodology is a philosophical field revolving around the action of knowledge to discover. Positivists use true scientific methodology, while interpretivists use pre-scientific methodologies. In this regard, Denzin and Lincoln (2005), and Creswell (2007, 2014) mentioned that one can practice educational research through (a) scientific and post-positivist methodologies; (b) constructivist and interpretive methodologies; (c) methodologies from transformative/pragmatic/critical theory.

In this study, my ontological and epistemological assumptions need both quantitative and qualitative data to answer the research questions. I used a quantitative approach to get an overview by survey and a qualitative approach to get insight to interpret the experienced phenomenon. The multiple realities through participants' perceptions and experiences about ICT-integrated pedagogy are the ontological standpoint in this study. It believes on both objective and subjective reality and respondents/participants are the sources of knowledge. The prime concern of the pragmatic approach of the research method is that every approach has some limitations so different approaches can be adopted to complement each other. Creswell (2007; 2014) mentioned that being able to mixed different approaches; make results stronger through various triangulations, like data triangulation, investigator triangulation and theory triangulation. Therefore, I did a large-scale survey on 240

students (Quan), analyzed the quantitative data; and came up with some quantitative findings about practices of ICT-integrated pedagogy to maintain equity in higher mathematics classes and pedagogical transformation. In the meantime, I selected 18 sample teachers, interviewed them (Qual) analysed the qualitative data; and come up with some qualitative findings. Then compare or relate both qualitative and quantitative findings and then make interpretations. Thus, I adopted a Quan-Qual convergent parallel research design.

Research Design

Research work is a systematic activity of searching and investigating reality about an issue. The characteristics of ‘systematicness’ in research entail a certain design or outline of the activities involved. A research design is a blueprint that shows how the elements of the research are coordinated to answer the research questions of the study. Creswell (2009) uses the term ‘research design’ to refer to the plan or proposal that involves the connection of philosophy, a strategy of inquiry, and specific methods and procedures to conduct research. To achieve the research goal, the research design gives guidelines to the researcher. According to Cohen, Manion, and Morrison (2005), “A research design is governed by the notion of fitness of purpose”(p. 90). The research design is a type of investigation under a research approach that give a specific directions or procedures for conducting the research (Creswell, 2014). The researcher selected the research design to answer the research questions as objectively, rapidly and economically as it is possible (Singh, 2008 p. 450). Likewise, the research approach is also considered as the assumption about the process to conduct an investigation or study. Creswell (2014) assume the research approaches as a plans and procedures for research process which extend the steps from wider assumptions to detailed methods to collect, analyze, and interpret the

collected data. These plans or decisions are mainly influenced by the philosophical assumption of the researcher, the nature of the research problem, personal experiences of the researcher, and the stakeholders of the study.

There is no single guideline or research design to conduct any educational research. In this concern, Creswell (2014) explore basically three types of research designs: qualitative, quantitative, and mixed methods research design. Quantitative research design believes on the post-positivist philosophical assumptions that derived and analyze data in numerical form. A quantitative research approach is the inquiry process that intends to examine the relationships between or among the variables using quantitative techniques (Creswell, 2014). This type of research includes numerical data, closed-ended questions, and facts for the discussion and interpretation of the results. The second type of research design is qualitative research design that derived from the qualitative approach. This research approach highlights the observation or experiences of researcher by exploring meaning and conclusions with depth interpretations (Creswell, 2014). The major principle of qualitative research design is that a research problem or research issue which is well understood to make its sense by comparing, contrasting, replicating, and categorizing its data resources (Mertens, 2010). This research approach enables us to develop new theories, to achieve a deep understanding of particular phenomena, or to give detailed information about the specific issue. Mixed methods research design is a type of research inquiry as the reflection of the mixed methods approach and its philosophical assumption. The mixed methods approach is an inquiry process about the research problem by using both quantitative and qualitative data to provide a more comprehensive understanding of the issue raised in research issue (Creswell, 2014). It emerged as a result of the debate and rigidity of quantitative and qualitative approaches in

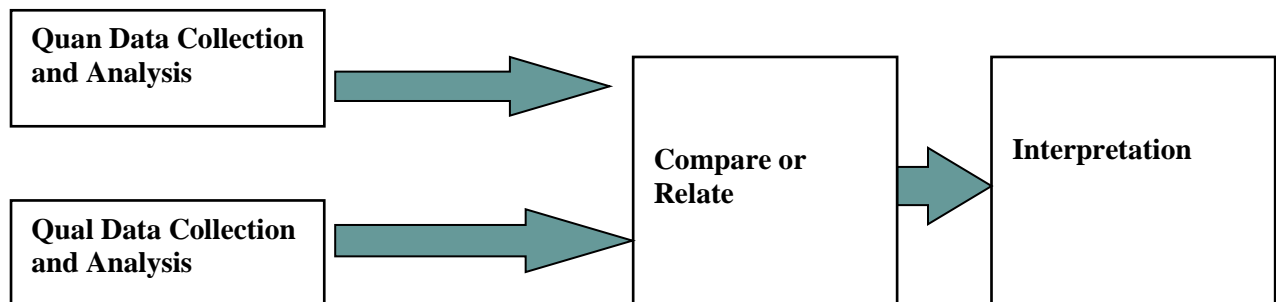
numerical and narrative logic. It is not just collecting and analyzing quantitative and qualitative data, but it combines and associates them in a standard form so that the overall study is focused on either qualitative or quantitative (Creswell, 2014). It mixes both types of data and uses separate designs based on philosophical assumptions, and on theoretical frameworks.

The qualitative and quantitative methods each provide different types of data, and each accesses different aspects of the phenomenon under the study, so that by integrating qualitative and quantitative findings, any study has increased scope, density and even increased validity (Morse & Maddox, 2013). In this regard, Creswell (2014) mentioned that a combination of both qualitative and quantitative approaches provides a more complete understanding of the research problem than the researcher uses a separate approach. This is a survey research that helps to find the experiences of teachers and perceptions of students about practice of ICT-integrated pedagogy regarding the issue of equity and pedagogical transformation. In my research the objectives demand both types of reality, thus I adopt Quan-Qual convergent parallel mixed method research design. I used a quantitative approach to get students' perceptions of ICT- integrated pedagogy through a survey method, and qualitative approach to get the lived experiences of mathematics teachers in higher mathematics classes as this would allow for rich and in-depth data.

The main reason researchers use a mixed or multiple methods research design is to maximize benefits obtained from both qualitative and quantitative methods in the same work. So, in this research, the wider range of source of information was considered by integrating both quantitative and qualitative research designs. The following convergent parallel design model was adopted in this research.

Figure 3. Research Design

Convergent parallel design (Creswell & Plano, 2011)



Needs of Using Mixed Methods

The guideline of any research is research method that must address the research problem. In a mixed method research, it is inadequate to develop multiple perspectives and a complete understanding about a research problem or research questions using only the quantitative approach or the qualitative approach. For example, the quantitative outcomes can be explained and validate using qualitative data. Alternatively, qualitative exploration helps to improve the relevance and strength of subsequent quantitative measurement that helps to draw more reliable and accurate findings. The investigator can explore new knowledge, complex phenomena, and interactions in addition to experimental settings by including qualitative aspect in mixed methods research. In this research, I also intends to explore the information about the practices of ICTs by taking a detailed picture of a system and show the realities of individuals. For this, there is necessaty to merge quantitative and qualitative data to develop a more complete understanding about the research problem. Beside this, to examine experiences of respondents along with outcomes, it is necessary to develop a clear picture; to compare, validate, or triangulate findings. (Plano, 2010). In mixed methods research, when a quantitative stage follows a qualitative stage, the researcher needs to develop a survey instrument to draw findings as suggested by qualitative results. When the quantitative stage is followed by the

qualitative stage, it helps to choose the best participants with whom to follow up or to explain the phenomena derived from the quantitative results (Plano, 2010). This study was intended to find the experiences of teachers and perception of students on the practices of ICT based pedagogy on higher education mathematics classroom, using both quantitative and qualitative approaches (mixed methods).

I used concurrent parallel mixed methods research design to demonstrate the quantitative result in numerical form and qualitative results in the text that helps authenticate the conclusions derived from quantitative analysis. The teaching strategies of various mathematics teachers with their experiences in the practices of ICT integrated pedagogy were explored by analyzing and interpreting both quantitative data and qualitative information in this research. The integration of both type of informations was done parallely. I used survey method to collect informations from the student participants about their perceptions towards the practices of ICTIP by their teachers. Qualitative study was very helpful to explore the lived experiences of teachers in their classroom practices from multi-dimensional perspective. The qualitative analysis agreed and disagreed the information derived from survey. I give conflicting remarks on the debated data with discussion and the agreed data were analyzed and interpreted from multiple perspectives to make clear meaning of a singular perspective.

Sample and Sampling Procedure

The sample is a representative group of informants from whom the data are obtained to make generalizations about the population (Patton, 2015) whereas the population is a totality of the respondents or cases that may be people, objects or events under a specific criteria to generalize the findings from the respondents (McMillan & Schumacher, 2010). Sampling of respondents in any research is the

selection of people to the research purpose within specific locations, different events, and activities to conduct the fieldwork (Tracy, 2020). In this research, the multi-stage sampling procedure was applied to select the research participants. Kothari (2011) states “multi-stage sampling is applied in big inquiries extending to a considerably large geographical area, say, the entire country” (p. 66). In his logic, there are two major advantages of this sampling design. The first one is, it is easy to administer multi-stage sampling than single stage sampling design because of the fact that sampling frame under multi-stage sampling can be developed in partial units. The second is possible to sampled large number of units for a given cost using sequential clustering under multi-stage sampling.

The following multi stage sampling was used in this study with five stage, as this study intends to find the experiences of teachers and perceptions of students towards the implementations of ICT integrated pedagogy in higher education mathematics classes across constituent campuses of TU and wanted to take sample of few colleges for the purposes.

Stage I: Stratified random sampling (Geographical regions)

Stage II: Cluster sampling (Science and education campuses)

Stage III: Random sampling (Bachelor and master level campuses)

Stage IV: Incidental sampling (Boys and girls)

Stage V: Purposive sampling (Sample teachers for interview and students for FGD)

In the first stage, stratified random sampling method was applied by dividing the constituent campuses of TU into two strata based on its geographical regions: Out of valley and within the Kathmandu valley. In the second stage, the campuses running Education and Science programs were selected using cluster sampling method.

Among 62 constituent campuses of TU, only 4 campuses running BSc programme, 4 campuses running MSc programme, 4 campuses running MEd programme and 6 campuses running BEd programme were selected. Then, in the third stage, random sampling method was used to select bachelors and master's level campuses.

Thereafter, the sample campuses were visited in fourth stage, and using incidental sampling method, boys and girls students were determined. Finally, purposive sampling was used to select teachers for interview and students for online FGD purpose. One teacher informant from each sample campuses and two sample students from eight campuses were selected from 12 constituent campuses of TU.

The sample size of the students for survey was determined using the formula,

$$n = \frac{N}{1+Ne^2}$$

Where, $e = 0.05$, $N =$ Population size, $n =$ Sample size

From the formula mentioned above, out of 602 students enrolled in bachelors and masters level majoring mathematics at science and education discipline, 240 sample size was determined using solvin's formula. The students from Education and Science discipline with equal numbers were selected including 120 students from bachelors level and 120 students from master's level. Likewise, one teacher from each level and discipline were selected and one-one group of students from bachelors and masters level including eight in number were selected for FGD. The students for FGD were selected purposively such that each group represents the students of education faculty and science faculty from out of Kathmandu valley and within Kathmandu valley. The purpose of conducting FGD is to find the view of students about the role of ICT integrated pedagogy for promoting equity and pedagogical transformation in their learning process and access of students on technology. The detailed distribution of the sample students is presented in the following table:

Table 1. *Student Samples Selected for the Study*

Faculty		Location		Total	
		Within Kathmandu Valley	Out of Valley		
Education	Level	Bachelor	20	40	60
		Masters	40	20	60
	Total	60	60	120	
Science	Level	Bachelor	30	30	60
		Masters	30	30	60
	Total	60	60	120	
Total	Level	Bachelor	50	70	120
		Masters	70	50	120
Total		Total	120	120	240

The sample teachers have academic qualification masters to PhD with five to 30 years teaching experiences. Also their job appointment was teaching assistant to professor (See appendix E). The detail distributions of sample teachers with their teaching level, discipline, and locations is presented below:

Table 2. *Teacher Samples Selected for the Study*

Faculty		Location		Total	
		Within Kathmandu Valley	Out of Valley		
Education	Level	Bachelor	2	4	6
		Masters	2	2	4
	Total	4	6	10	
Science	Level	Bachelor	2	2	4
		Masters	1	3	4
	Total	3	5	8	
Total	Level	Bachelor	4	6	10
		Masters	3	5	8
Total		Total	7	11	18

Data Collection Tools

According to Denzin and Lincoln (2005), researchers can use multiple tools for data generating process to infer and interpret a phenomenon. As a mixed method research design, both quantitative and qualitative data was utilized in this study. In this context, I used four data collection tools for this study: viz. survey questionnaire, FGD guideline, interview guideline and class observation guideline.

Survey Questionnaire

Questionnaire is one of the crucial and common tools to collect data for the research studies. It is defined as ‘a form used in a survey design that participant in the study complete and return to the researcher’ (Creswell, 2012, p. 382). It is broadly used and important tool that provides structured often numerical data. According to Cohen, Manion and Morrison (2005, p. 264) the questionnaire in research can be categorized into structured, semi-structured, and unstructured types. The type of questionnaire depends on the nature and size of the sample. The larger sample size requires more structured questionnaire with closed and numerical questions. For smaller size sample, less structured more open word-based questions are more useful.

Questionnaires are useful in the research that they are reliable and objective, and that they offer respondents anonymity. Thus, in this study, I prepared one set of survey based questionnaire (see appendix A) to collect the perceptions of students about ICT integrated pedagogy. The quantitative data in five-point Likert scale was collected through questionnaire. The questionnaire consisted of different types of questions such as dichotomous/multiple choice questions, Likert type questions, and open-ended questions. Altogether, there were five multiple choice questions, 61 Likert type questions, and seven open-ended questions. The survey questionnaire comprised three major components; Input, Implementations and Output on ICT

integrated pedagogy. The items were developed based on availability of learning resources, its implementation by the teachers to manage equitable learning environment and performance of students after implementations. It helps to fulfill the first objective of the study.

Interview Guidelines

Interviews constitute one of the data collection methods in this study. It is a common practice in research tradition to gather qualitative information by formulating interview guidelines (Flick, 2006). Nevertheless, I developed one set of interview guide (see Appendix B) prior to the fieldwork in order to provide the study with a proper focus and make sure that issues surrounding teachers' experiences towards the practices of ICT integrated pedagogy to teach mathematical contents of bachelors and masters Level of TU. These questions were used rather flexibly, subjected to modification and adaptation as the study unfolded with new insights in the fieldwork situation. The interviews were carried out following the initial task of building a climate of trust and developing preliminary rapport with the interviewees. The interview guideline consisted of the access on technology, motivating factors, teacher's preparedness, teachers' strategies, creativity and collaboration, criticality and co-operation, change management and opportunity and challenges of the ICT integrated pedagogy. The qualitative data were collected to fulfill the second objective of the study.

FGD Guidelines

The focus group discussion involved seven to ten in each group. While conducting the discussion, I was well aware of the fact that there was a high possibility of the students being less-exposed and reluctant in one-to-one interview setting. Another assumption was that that interaction of group participants stimulates

talking and makes it easier for them to open up. Therefore, group interviews were scheduled for the students with the purpose of finding the students perceptions on the practices of ICT integrated pedagogy by their teachers in mathematics classes. With these considerations, a semi-structured FGD guidelines (See appendix C) was designed in order to conduct focus group discussion with students and the focus of these interviews was to gain insight into how the students perceived. The FGD was conducted to find the role of ICTIP in enhancing accesses of resources, software used by students to study mathematics, challenges and opportunities of ICTIP, and institutional support for teachers and students. The qualitative type of data obtained through this tool was obtained to fulfill the second objective of the study.

Class observation Protocol

The class observation protocol was another data collection tool to find the real practices of ICT based pedagogy in mathematics class. Beside this, the observation helps me to find the teacher's strategies to develop equity pedagogy and participation of students from diverse group in mathematics class. The observation tools is used as very important tool for collecting data in the qualitative research. It is considered as important tool to collect first-hand information in a natural setting for qualitative research. In qualitative research, class observation usually consists of "detailed notation" of behaviors, actions and the situations surrounding the events and behaviors (Best & Kahn, 2009).

In this research, an unstructured class observation protocol (see Appendix D) was used. It was done to observe the classroom activities of research participants to cross-check the activities they had done and their lived experiences they expressed in their interview time.

Reliability and Validity of Tools

The reliability of tools is important for getting accurate and reliable information from respondents. Reliability is concerned with correctness and accuracy of tools. It essentially refers to the uniformity and ability to be reproduced consistently across various timeframes, tools, and respondent groups (Creswell, 2014). For reliability of research tool, it must demonstrate that if it was to be carried out on a similar group of respondents in a similar context, then similar results would be found (Denzin & Lincoln, 2005). The terms trustworthiness, credibility, and consistency are more useful in qualitative research for reliability. The reliability and validity of tools in this study was established by following methods.

The reliability and validity of survey questionnaire was established by a pilot study. The survey items were administered as a pilot study to 22 students from CDED during the academic year 2020. The items of the survey were prepared based on availability of learning resources, its implementation and performance of students after implementations. The minimum time to complete the survey was 30 minutes and maximum time was 45 minutes. After survey administration, data entry in SPSS was carried out. The survey questionnaire consists three variables viz. input, implementation and output including 17 constructs, 61 items. The five-point Likert scale was used on each items of the questionnaire. Among them, item number 18 and 20 were negative in the scale. Hence, they were recoded into positive scale by giving the value 1 to 5, 2 to 4 and so on. The reliability of the questionnaire was ensured by applying Cronbach's alpha. Overall, the Cronbach's alpha reliability value 0.918 was found to the questionnaire for internal consistency of all the 61 items. This indicates that the survey questionnaire is reliable. The following table presents the Cronbach's alpha coefficient of the students' questionnaire:

Table 3. *Reliability Statistics*

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	No of Items
0.918	0.923	61

To test the reliability of survey questionnaire on the basis of input, implementations and output for ICTIP, separate test was conducted. The Cronbach's alpha coefficient on input, implementations and output for ICTIP was found to be 0.918, 0.916 and 0.916 respectively. This indicates that the survey questionnaire on the basis of input, implementations and output is reliable. The following table shows the average Cronbach's alpha value and weighted mean of three variables:

Table 4. *Reliability Statistics of Input, Implementations and Output*

Indicators	Average of Cronbach's alpha	Number of Items
Input	0.918263	19
Implementation	0.915722	18
Output	0.91575	24

The further analysis informed that all the statements to evaluate the input of ICTIP are reliable (See appendix L). All the statements related to the input of ICT integrated pedagogy are reliable with Cronbach's alpha value between 0.915 and 0.922. There are 19 statements in this survey questionnaire related to five constructs: Human resource, Infrastructure, Digital resources, Academic environment, Curriculum integration to find the status of input for technology based pedagogy are reliable. This also conclude that the perceptions of students about the input of different ICT tools, human resources, infrastructure, academic environment and ICT

friendly curriculum are not deviated and there is consistency on perception of students about input for practicing ICTIP with standard deviation between 0.64 and 1.31. This shows that there is consistency between the perceptions of students.

Similarly, the Cronbach's alpha value of all statements relating implementation of ICTIP was found 0.916 (See Appendix M). All the statements related to the implementations of ICT integrated pedagogy are reliable with Cronbach's value between 0.914 and 0.924. The analysis of each statements related to implementation of ICTIP informed that all the statements are reliable.

There are 18 statements in this survey questionnaire related to six constructs: Regularity, Management, Pedagogical process, Intra and inter communication, Opportunity and challenge, Assessment and evaluation on implementations of ICTIP. This concluded that the perceptions of students about the teacher's regularity, class management and regularity, pedagogical process, intra-inter communication between students and teachers, opportunity and challenges to implement ICTIP and assessment and evaluation process on their institutions are not so deviated. It also concluded that there is consistency on the perceptions of students about implementations of ICTIP by their teachers at mathematics classes with standard deviation between 0.75 and 1.15.

Likewise, the Cronbach's alpha value of different statements representing output of ICTIP was found 0.916. All the statements related to the output of ICT integrated pedagogy are reliable with Cronbach's value between 0.913 and 0.919 (See appendix N). There are 24 statements included in this survey questionnaire based on six constructs: Student achievement, shift in pedagogy, outcome in society, change on attitude, promoting equity, pedagogical transformation related to output of ICTIP.

The result from data concludes that the perceptions of students about the achievement of students, pedagogical shifting through ICTIP, outcome of students in

the society, change on students and teachers attitude towards ICT, role of ICT to promote equity and pedagogical transformation due to ICTIP are not so deviated. It also concluded that there is consistency on perception of students about output of ICTIP on mathematics achievement with standard deviation between 0.53 and 1.23.

The reliability of interview and FGD guideline was ensured by triangulating among teachers' responses. Creswell (2018) has mentioned that reliability of interview can be established by pilot study and responses triangulation. For this, the interview guideline was piloted with four teachers of CDED during academic year 2020. The interview questions were asked to teachers and responses on their experiences was recorded. The construct validity of interview guideline and FGD guideline was ensured by expert judgments (Denzin & Lincoln, 2005). Therefore, the content and construct validity of interview and FGD guideline was ensured. The standardized observation form was used for the classroom observation.

Trustworthiness of Qualitative Data

The trustworthiness of qualitative data referred to be credibility, transferability, conformability, and dependability of study finding. Trustworthiness is about the rigor of a study refers to the degree of confidence in data, interpretation, and methods used to ensure the quality of a study (Denzin & Lincoln, 2005). In this study, I established the trustworthiness of the study by presenting the data with natural setting.

The credibility is known as how confident I am in the truth of the findings. To establish the credibility, the quantitative and qualitative data triangulation was done. Transferability is referred as how do I demonstrate the findings of research study that will be applicable to other contexts. To establish transferability, the thick description was used to utilize the research findings. Conformability is the degree of neutrality in

the research findings. The potential bias was avoided and code was applied. The dependability is the extent that the study could be repeated by other researchers and that the findings will be consistent. For the member checking, I send my transcripts and field notes to some of the participants to check for perceived accuracy and reactions. I also shared part of my analyses and interpretations of data with some of the informed participants as part of the process of analyzing and writing. A few of them wrote back and agreed that my ‘reconstructions’ are fair, then I incorporated their comments into the final narratives. This ensures that the findings will be consistent and trustworthy.

Data Collection Procedure

In this research, I collected ‘multiple forms’ (Creswell, 2018) of data from ‘multiple sources’ (Mathison, 1988) using ‘multiple methods’ (Cohen et al., 2018). The methods I used to gather the qualitative data through interview, FGD, and observation. Accordingly, I administered survey questionnaire for sample students to collect quantitative data. I collected data to find the present practice of ICT integrated pedagogy in higher mathematics education classes. For this purpose, teacher’s experiences to manage higher education mathematics class using ICT integrated pedagogy was collected through in-depth interview.

Survey

The students’ perceptions towards ICT integrated pedagogy in higher education mathematics class was collected through the questionnaire including five-point likert scale. I collected all the information myself from the research field. I visited each selected campuses for the survey and Interview and described my research work to the campus chief of each campuses visited. Permission from the campus chief was gained but it would not be sufficient for collecting data from

participants. So, I built a good rapport with the department head and subject teachers and explained to them the study design, and the data to be collected for the study. After this interaction, I allowed to enter the classroom and the subject teacher informed his/her students about the presence of the researcher and asked the students for their cooperation in the researcher's works. Similarly, I gave instructions and clarification to the students what they had to do as respondent so that students feel free to respond on my survey questionnaire. All 240 sample students fully responded to the questionnaire then I collected the questionnaire from students.

Interview

Interview is one of the important methods to collect qualitative data because it helps to collect the information in natural setting. The interview is basically used in qualitative research designs such as: case study, phenomenology, narrative inquiry, ethnography and mix methods research. Interview is described as professional conversation with a specific purpose (Best & Kahn, 2006). Interviews are valuable and applicable in qualitative research for several reasons. Firstly, it allows researchers to gather information and context about issues that might not be easily observed or accessed. Secondly, it is particularly useful for studying very specific topics. Finally, interviews add depth and complexity to other data sources (Tracy, 2020). In qualitative research, we generally used three types of interviews: structured interview, open interview and semi structured interview to collect qualitative data.

The open interview is in-depth and semi structured in nature. The purpose of this type of interview is to explore lived experiences, views or feelings of the respondents. In semi structured interview, meaning is jointly created through interaction with respondent in which analysis explores their understanding through a careful reading of the interaction (Creswell, 2018). In semi structured interview, the

participants are interviewed on the basis of the interview guide. Likewise, conducting an interview requires skill and experience so that the responses could be gathered in good faith. The purpose of open-ended interviewing is not to put things in someone's mind but to assess the perspective of the person being interviewed” (p. 265).

The method I used to collect the qualitative data was interview. I employed the “open-ended semi-structured interview” (Creswell, 2007; Denzin & Lincoln, 2011) to elicit the lived experiences of teachers on the practices of ICT integrated pedagogy. In the second phase, as per preference of participant teachers, I conducted interviews with them either in Nepali or English (their preferred language) or mixing both languages so that they could express themselves clearly and feel more comfortable in interaction. Then I focused on their experiences, and feelings towards the practices of ICT in their pedagogical process. The atmosphere of the discussion was informal, and I was cautious enough to respect their opinions but not to judge them. The interviews were audio/video recorded after teachers’ permission and transcribed them in Nepali later. I again translated the transcribed data into English and shared the translated transcripts with teachers I interviewed for respondent validation. The interview lasted for half an hour to an hour. Follow-up interviews were made several times through informal meetings and telephone and messenger calls for clarification and further exploration of the issue. The pseudonyms T₁, T₂,....were assigned to all 18 participant teachers for anonymity and confidentiality in the research (Bryman, 2012).

Focused Group Discussion

The focused group discussion is an important tool used in qualitative data collection in social science research during 1920s as a market research tool and it is still important in other research areas (Greenbaum, 1998). In focused group discussion, an informal or formal group discussion holds being focused on the

research objectives or research problem to gather qualitative data. The role of researcher in focus group discussion is moderator for the group of participants by raising the issue, keeping the discussion and encouraging them to participate fully in the interaction. In FGD the discussion is mostly based on some sets of objectives and the research problems. Moreover, it believes on flexible research method, i.e., it can be used either as a qualitative method or combined with quantitative methods (Wilkinson, 1999). The researcher in focus group discussion need to be well prepared by making the discussion natural to deal with ethical issues such as each member of the group may participate on discussion without any hesitation.

To obtain data quickly from a large number of participants, focused group discussion is more naturalistic than interviews. The participants discuss, debate, and disagree about key issues in focused group discussion (Jarrett, 1993). In this study, as the data were collected during the Covid-19 pandemic, the FGDs were conducted online using my personal Zoom ID. This oneline FGD was also relevant because I had to include the students in a group from the campuses within the Kathmandu Valley and those from outside of the valley.

Class Observation

Class observation is another very important data collection tool in qualitative research that is prepared and done on ethical consideration of the participants. In my research, I used class observation as a tool to collect the activities of teachers and students in the practices of ICTIP in their classes. I did participant classroom observations (35–45 minutes each) during the data collection periods. I sat on the bench of the last row to minimize the obtrusive researcher effect in the class, which allowed me to see students without being a distraction. I created a natural environment to promote trust between the researcher and the participants in

classrooms being familiar with teachers and students. For this, I engaged with them in informal conversations; I built rapport and collegial relations with teachers by talking about their experiences towards the practices of ICT integrated pedagogy in higher education mathematics classes. I observed four online and four face-to-face classes of the bachelor and master's level to observe the research participants' activities in order to cross-check how they had used ICT tools in their classroom practices to teach mathematics and perceived teachers' practices of ICTIP during the interview and FGD session. The real situation of mathematics class was observed to find the teachers' strategies and classroom behavior they used in their classroom. The detailed of the observed class and the teachers' strategies in their classes is presented in Appendix O.

Data Analysis Procedure

Data analysis is a process of drawing useful information from the collected data in order to draw conclusions and make decisions. According to Bogdan and Biklen (2007, p 159), data analysis is the process of systematically searching and arranging of collected data and other information accumulated to come up with findings. The analysis of qualitative data requires an understanding of making sense of the data so as to answer the research questions formulated in the research. Furthermore, according to Richardson (2000), qualitative data analysis is not just making sense of the world, but also making sense of our relationships to the world to describe the phenomenon. Qualitative data analysis and interpretation is the activity of working with data—organizing into small units, coding, synthesizing and developing themes and explaining the ideas in relation to theories and literature to make them understandable (Bogdan & Biklen, 2007). Likewise, quantitative data analysis is a set of mathematical procedures for organizing, summarizing, and interpreting information collected by the researcher (Muijs, 2004). Different types of statistical techniques are

useful for analyzing quantitative data. According to Creswell (2012), there are several interrelated steps in the process of analyzing quantitative data such as preparing data for conducting descriptive, correlational or inferential statistics; reporting the results using Tables, Figures, and Graphs and discussing the key results; and interpreting the results.

Before analyzing the data of this study, the raw data collected through different tools were systematically organized in data analysis format. Firstly, the responses of students obtained from survey were encoded in the SPSS software (Version 20). Secondly, for the comparison, a chi square test of independence and t test were used as per the nature of data. The preliminary analysis reveals that, the data obtained through the survey questionnaire was found to be normal with kurtosis value 1.042 and skewness value -0.625. A Chi-Square test of independence was employed to see the association between variables. The relationship between perceptions of students' and gender was examined by using t test. Besides, to analyzed the quantitative data, I also used the person's correlations, Analysis of Variance (ANOVA) test and multiple regression analysis.

Content analysis (Miles & Huberman, 1994) was used to analyze the data in this study based on interviews, observation, and Focus group discussion. The general inductive method as described by Thomas (2006) was applied to analyze qualitative data. After I collected the qualitative data using various tools, and techniques from multiple sources, I interpreted them thematically. For this purpose, all interviews and FGD were first audio-recorded by obtaining the informants' permission. After that, I transcribed the data, which were collected in multiple forms from multiple methods, using the recorded materials and I translated them. Then, I added the text documents to the ATLAS.ti project and interpret the information using ideas from various

scholars (Chase, 2018; Saldana, 2013) for qualitative data analysis procedure in general. Similarly, to interpret the qualitative data with ATLAS.ti, I utilized the concepts of several scholars (e.g., Friese, 2022; Soratto, Pires, & Friese, 2020) especially to add the documents and group them, code the information, categorize the codes, and create various themes (basic, organizing, and global). There were 581 quotations, 391 codes, 27 basic themes and 14 global themes on the data obtained from teachers' interview and 139 quotations, 50 codes, 16 basic themes and 8 global themes on the data obtained from students' FGD. The cross-validation of obtained data was maintained through observation of mathematics class. The qualitative data was interpreted in the form of texts, narrations and reflective points relating with the learning theories and results of the empirical research.

Integration of Qualitative and Quantitative Data

I have applied convergent parallel mixed method design in this research. In this design, both qualitative and quantitative data were collected and analyzed separately, but the results were then merged or integrated to provide a more comprehensive understanding of the research questions. To mix the qualitative and quantitative data, I have used the triangulation approach, which involves comparing and contrasting the results from two types of data to identify patterns or themes or to confirm or disconfirm findings. The information obtained from the focus group discussion and the participants' class observation was merged into the information obtained from the semi-structured interview of the eighteen participant teachers. The process of triangulation corroborates evidence from different individuals, types of data, or methods of data collection ensure the accuracy of the information (Creswell, 2007). Further, Creswell states, "This ensures that the study will be accurate because the information is not drawn from a single source, individual, or process of data

collection” (p. 280). After analyzing the data I integrate the results by comparing the themes or patterns that emerged from the qualitative data with the quantitative results.

I have triangulated across the data sources, methods, and theories that I took the detailed descriptions of the research process to search multiple sources of information and form themes or categories (Creswell & Miller, 2000, p. 126) from the data. For this purpose, I have collected the data from multiple sources (i.e., teachers and students) using multiple methods (i.e., interview, observation, and survey questionnaire), and have analyzed, interpreted, and discussed the results based on the research questions that I have formulated.

Ethical Considerations

The word ethics is derived from the Greek word ‘ethos’ which means ‘character’ i.e. moral principles of the researcher that suggest how to act in a given situation. Research ethics refers to the code of conduct for investigators guiding to the desirable behavior. According to Creswell (2014, p. 92), the ethical issues in research that need to be considered are extreme, and that are related to the different phases of research process such as the beginning of the study, data collecting, storing, and analyzing phase. Likewise, in the sharing and reporting of the findings phase, the ethical issue was considered. As a researcher, it is necessary to be abide by the compulsions of some professional ethics.

In this research too, I made much effort to maintain the balance to address any apparent prejudices that might be developed from my side as the researcher as much as possible. I selected the institution randomly, to the best of my conscience; I do not have my personal prejudice of any kind to select the participants. Before collecting the data, I got consent from participants and ensured them about confidentiality and anonymity were also maintained. I do my best to make the interactions more natural.

It was ensured that, after transcribing the interviews, the audios are kept safe.

Likewise, all the information obtained used for the purposes of the research. The trustworthiness and member checking were also maintained for the validation of the result. I was rigid on the methodology that I proposed in the beginning and what one is supposed to do in these types of studies.

Chapter Four

Perceptions of Students and Teachers on the Practices of ICTIP

This chapter focuses on the analysis of the quantitative data collected from survey questionnaire. The study aimed to analyze the experiences of teachers and perceptions of the students towards the practices of ICT integrated pedagogy in higher education mathematics classes. Both quantitative and qualitative data were collected and further analyzed. Statistical Program for Social Science (SPSS version 20) was used to analyze quantitative data using both descriptive and inferential statistics. The statistical tests like; percentage, weighted mean, standard deviation, correlation, Chi-square, t test, multiple regression and ANOVA were used for quantitative data analysis. The students' perception was measured based on three variables: input, implementation and output. The variable input includes five constructs (human resource, infrastructure, digital resources, academic environment, curriculum integration), implementation consists six constructs (regularity, management, pedagogical process, intra and inter communication, opportunity and challenge, assessment and evaluation) and output includes six constructs (student achievement, shift in pedagogy, outcome in society, change on attitude, promoting equity, pedagogical transformation). They were analyzed and the results were compared on the basis of gender, caste and ethnicity, location, level and discipline. The difference between and among groups was tested at 0.05 level of significance.

The chapter has been organized in four major sections; section I discusses the general practices of information and communication technology in learning mathematics, section II discusses the perceptions of students towards the practices of ICTIP in pedagogical practices, section III discusses the comparison of students'

perceptions and section IV discusses the relationship between students' perceptions on different constructs towards the practices of ICTIP in their pedagogical process.

General Practices of ICT in Learning Mathematics

The general practices of ICTs in learning mathematics was found on the basis of availability of ICT resources, time devoted by the students in their daily routine using ICT.

Availability of ICT Resources in Use

The mathematics students of bachelors and master's level use ICT tools for accessing resources, sharing reading materials with their friends and teachers, solving mathematical problems, and preparing their project work. The first concern in the survey questionnaire was to find whether the students use any ICT tools to learn mathematics or not. In this concern, I found that all the respondents (N=240) use any one of the ICT tools like; Mobile phone, Laptop/ computer, computerized information system, CD ROM, Tablet, Interactive whiteboard, Multimedia projector, TV, Radio, Telephone, Offline software program, LMS platforms such as Moodle, Mathematical Software, Internet assisted software tools (You tube, Face book, Email, Google docs, Wiki, Imo, Viber, Skype, Web sites etc.) to learn mathematics.

My field observation in the sample colleges found that there is moderate level of ICT infrastructure and equipments in order to teach mathematical concepts in the class. They are quite resourceful regarding the ICT-related infrastructures and equipment. In this concern T₁₄ said, "The electric power supply and internet facility in our campus is good, though load shading and internet fluctuations disturbs to conduct ICT based teaching smoothly." Only one third of the sample colleges have e-library, computer lab, and separate IT department to ease their teaching and learning environment ICT-friendly. Different ICT tools were used by the teachers and students

on their teaching- learning process. The students use ICT tools not only within the campus compound, but also in their campus off time. They perceived that ICTIP helps them for assisting their life-long learning. As a response to the question, ‘What ICT tools/software do you use for visualizing abstract concepts of mathematics?’ the student participant S₈ said, “The device and software that I used in learning are; Laptop, MS PowerPoint, Mathematica, Geometer's sketchpad, Maples, Khan academy, Microsoft math solver, GeoGebra, photo math and math studio.”

In this concern other student S₆ said; “The tools that I use for accessing information are Wiki, YouTube, Google, Blogs, computer etc. and I use some apps like google meet, MATLAB, GeoGebra, Mathematica, and sometime Google to search the problems I can't solve”.

The view of students informed that some of the students who have internet facility and appropriate device in their home use advanced ICT tools and mathematical software to visualize abstract concept of mathematics. The above view of two student respondents shows the trends of students’ engagement on ICT tools and competencies of students on technology. This inform that some of them were found competent on ICT than their teachers because they compete with new generation and struggle for the betterment. Supporting this view, the teacher T₇ expressed;

Some of our students are very creative, cooperative, and collaborative in classes. They are also competent in technology that increases the interaction between teachers-students and students-students. There are some extraordinary students for using technology in each class and they facilitate on the use of technology to us as well. Such students present their project work very nicely.

This view of teacher indicates that the student's competencies on technology make the teaching learning process effective. Some technologically skilled students assist their teachers to handle the learning platform properly for collaborative activities in mathematics classes. The activeness of students in the class using ICT tools makes the classroom activities interactive and live. The access to resources by using basic ICT tools was less challenging to the students as there were many ways and tools for finding learning resources to get opportunities for further knowledge. The teacher T₅ in the interview shared his experience as;

There are mainly three ways that the students can access resources: The first is the internet mediated communication with the ICT tools like E-mail, Facebook, YouTube, Viber, Skype, Instagram. Secondly, there is e-library and google search through which they can search resources and got knowledge from it. Thirdly, they can be involved in direct communication in the class and discuss about their concern.

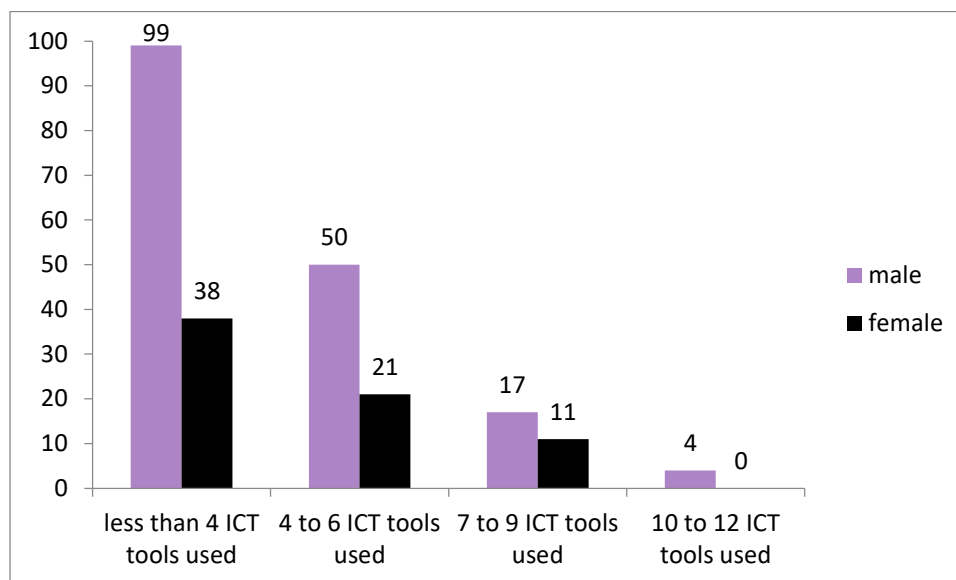
The response of the participant teacher reveals that during the pandemic the face to face interaction was not possible and the students mostly used ICT tools for teaching learning process. They depend on the virtual classes of teachers and e-resources for knowledge construction. Most of the students use Google search for learning resources and YouTube for classroom videos. In this digital era, students can develop deeper understanding of mathematical concepts and can improve their skill by incorporating both tools and resources.

Practices of ICT Tools by Students

A majority of students used less than expected number of ICT tools in their classroom. In this study, my concern was how many ICT tools the students used to learn mathematics. The response of the students shows that out of 240 respondents,

137 (57.1%) respondent used less than 4 ICT tools, 71(29.6%) respondents used 4 to 6 ICT tools, 28(11.7%) respondents used 7 to 9 ICT tools and only 4 (1.7%) respondents used more than nine ICT tools to learn mathematics.

Figure 4. *Number of ICT tools Used by the Students*



The above figure shows that, majority of the respondents use less than four ICT tools to learn mathematics. And only four respondents use more than nine ICT tools due to the resource constraints. In this concern, the student S_{12} say;

The major challenge to use different ICT tools in learning mathematics is a financial problem, lack of resources, poor access of internet and non-availability of mathematical software. Due to geographical diversity and unequal resource division in Nepal, we students, face challenges on learning. Beside these we cannot effort for expansive mathematical software helps to facilitate on visualizing abstract concept of mathematics.

Teachers and students face many challenges like; insufficient resources, poor access of internet, unavailability of genuine mathematical software, and diversify classroom situation to integrate ICT in their teaching learning process. Supporting the view of his friend the student respondent S_1 on FGD say; “Due to unaffordable

genuine mathematical software and unavailability of modern ICT equipment, I use crack version or trial version mathematical software only.” This narrative of students informed that there is lack of infrastructure and mathematical software to integrate ICT into pedagogical practices. The financial problem is another challenge to use advanced ICT tools and genuine mathematical softwares. The lack of strong bandwidth internet facility due to geographical difficulties is another challenge to integrate ICT in pedagogical process.

To find the association between accesses of ICT resources and student related variables like; gender, level, discipline and location of the college, the chi- square test of independence and percentage was performed and found the following result:

Table 5. *Access of Students on ICT Tools*

		ICT tools used by students				Total	χ^2
Variables	Groups	less than 4 tools	4 to 6 tools	7 to 9 tools	10 to 12 tools		
Gender	Male	58.24%	29.41%	10%	2.35%	170	3.176
	Female	54.29%	30%	15.71%	0%	70	
Faculty	Education	57.5%	30%	11.67%	0.83%	120	1.021
	Science	56.67%	29.16%	11.67%	2.5%	120	
Level	Bachelor	63.33%	24.17%	11.67%	0.83%	120	5.023
	Masters	50.83%	35%	11.67%	2.5%	120	
Location	Withinvalley	61.61%	22.5%	15%	0.83%	120	8.239
	Out of valley	52.5%	36.67%	8.33%	2.5%	120	

The analysis of data from above table reveals that gender, discipline and level of students' enrollment have no association with access of ICT tools but there is

association between access of ICT tools and location of campuses. For finding the number of ICT tools used by students in their teaching learning process, the perceptions of students revealed that among 240 sample students, majority (more than 50%) of the students on each category use less than four ICT tools to access information and resources. Likewise, 71 students use 4 to 6 ICT tools, 28 students use 7 to 9 ICT tools and very few (only 4) students use 10 to 12 ICT tools in their learning process. This table also illustrates that none of the girls students use more than nine ICT tools to access information and resources. More interestingly, out of Kathmandu valley students use more ICT tools to compare with the students within Kathmandu valley even though the students within Kathmandu valley got better access on technology than the students from out of valley. Likewise, students from science faculty use more ICT tools than students from education faculty, male students use more ICT tools than female students and master's level students use more ICT tools than bachelors level.

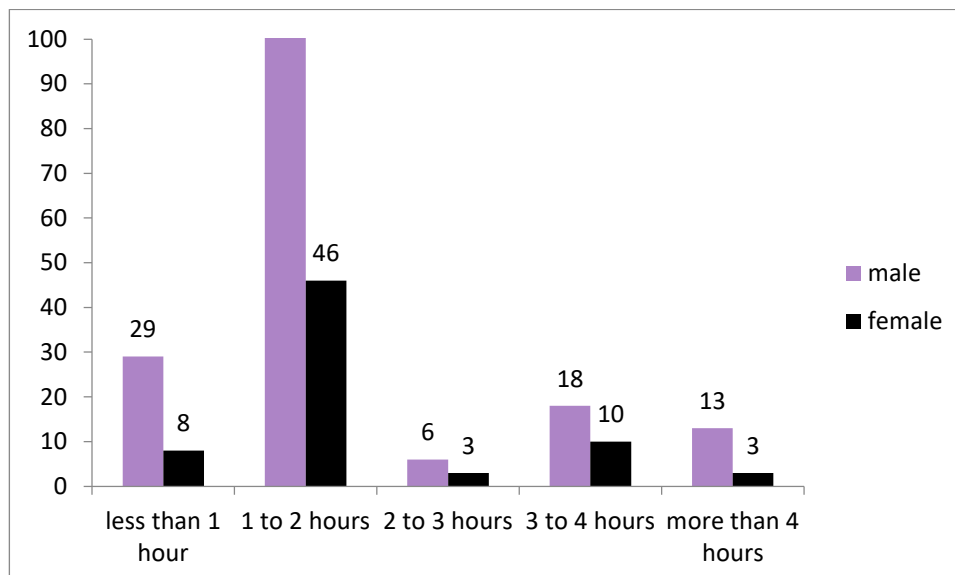
The above table informed that the association between the variables access of ICT and gender was not found significant, $\chi^2 (3, N = 240) = 3.176, p > 0.05$. Therefore, the result concluded that, there is no association between the variables access of ICT tools and Gender. This shows that there is equal opportunity for girls and boys on ICT access. Likewise, the association between the variables access of ICT tools and faculty was not found significant, $\chi^2 (3, N = 240) = 1.021, p > 0.05$. Therefore, this result concludes that there is no association between the variables access of ICT tools and faculty of the students they enrolled for higher education. Also, the association between the variables access of ICT tools and level was not found significant, $\chi^2 (3, N = 240) = 5.023, p > 0.05$. Therefore, it concludes that there is no association between the variables access of ICT tools and enrolled level of

students. This result inform that the enrollment level of the students does not matter on the access of ICT tools but it matter on the economic condition and interest of their parents. But, the association between the variables access of ICT tools and location was significant, $\chi^2(3, N = 240) = 8.239, p < 0.05$. Therefore, it is concluded that, there is an association between the variables access of ICT tools and location of students. This indicate that the geographical location of the campuses matter on the availability and access of ICT tools to the students. The students within Kathmandu valley got better access on technology than the students out of Kathmandu valley. The students from remote area of Nepal have low access on internet facility as well as electricity facility. This creates digital divide among students.

Students' Practices Using ICT Tools on Learning

More than sixty percent of the students spent one to two-hour time in their study using ICT tools each day. The male students spent more time than the female students in the use of technology in learning mathematics. In another question that on the average, how many hours do you spend on learning Mathematics using ICTs each day? The following result was found:

Figure 5. *Students Engagement on Learning Using ICT*



The above figure shows that majority (62.5%) of the students spent one to two-hour time in their study using ICT tools each day. The opinion of the students also illustrate that male students spent more time than the female in learning mathematics. The response of students shows that 37(15.4%) respondents spent less than one hour, 150 (62.5%) respondents spent 1 to 2 hours, 9 (3.8%) respondents spent 2 to 3 hours, 28 (11.7%) respondents spent 3 to 4 hours and 16 (6.7%) respondents spent more than 4 hours to study Mathematics using ICTs each day.

The students use these tools to search reading materials and classroom video and some of them use mathematical software like; GeoGebra, Mathematica, and SPSS for mathematical calculation. The opinion of students S_3 is, “To learn the derivatives, antiderivatives, algebra and sets I use Mathematica, I use GeoGebra for visualizing abstract concept of mathemtics like; conic section, tangent and normal, differential geometry and projective geometry and SPSS on solving statistical problems.” The view of student informed that students use mathematical software to visualize two dimensional and three dimensional geometrical concepts, limiting value, tangent and normal as well as made their work easy and significant. The students believe that the use of technology made the unclear concepts more clear and memorable in their learning process. This wiew of the students shows the importance of ICT tools in mathematics learning specially to visualize the abstract concepts.

To find the association between numbers of hours used to learn mathematics with ICT tools each day and student related variables like; gender, level of enrollment, discipline, and location the percentage and chi square test of independence was applied. The analysis of the students response got the following results:

Table 6. *Time Spent by the Students in Learning Mathematics Using ICT*

		Number of hours spent in learning mathematics with ICT					Total	χ^2
		less than 1 hour	1 to 2 hours	2 to 3 hours	3 to 4 hours	above 4 hours		
Gender	Male	17.1%	61.2%	3.5%	10.6%	7.6%	170	2.68
	Female	11.4%	65.7%	4.3%	14.3%	4.3%	70	
Faculty	Education	10.8%	65%	3.3%	13.4%	7.5%	120	4.44
	Science	20%	60%	4%	10%	6%	120	
Level	Bachelor	16.6%	69.2%	0%	10%	4.2%	120	13.8
	Masters	14.2%	55.8%	7.5%	13.3%	9.2%	120	
Location	Kathmandu						120	
	valley	18.3%	50%	6.7%	15.8%	9.2%		18.6
	Out of valley	12.5%	75%	0.8%	7.5%	4.2%	120	

(N= 240)

The above table informed that boys spent more time than girls in learning mathematics. From the five groups relating time for learning mathematics with ICT tools each day in their learning process, 37 students use less than one-hour time to learn mathematics using ICT tools each day, 150 students use ICT tools 1 to 2 hours in learning each day, 9 students use 2 to 3 hours to learn mathematics using ICT tools each day, 28 students use 3 to 4 hours to learn mathematics using ICT tools each day, and 16 students use more than 4 hours to learn mathematics using ICT tools each day. This data illustrate that male students spent more time than the female and bachelor level students spent more time than master's level with ICT to learn mathematics.

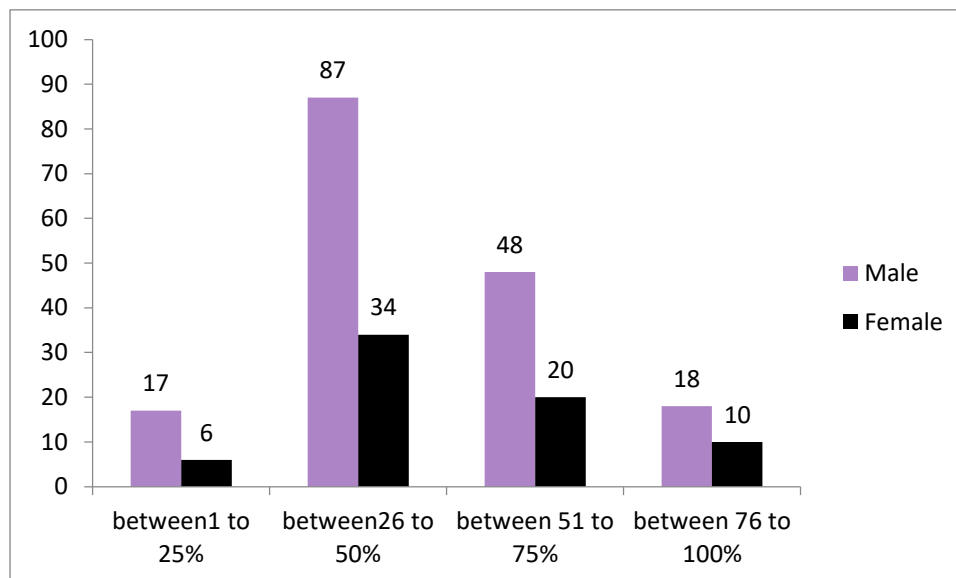
The above table also shows the association between time for learning mathematics with ICT tools each day by the students with Gender, caste, faculty, level and location of students. The association between the variables time for learning mathematics with ICT and gender was not found significant, $\chi^2 (4, N = 240) = 2.680$, $p > 0.05$. Therefore it is concluded that, there is no association between the variables time for learning mathematics with ICT and Gender. Similarly, the association between the variables time for learning mathematics with ICT and was not found significant, $\chi^2 (4, N = 240) = 4.443$, $p > 0.05$. This concludes that, there is no association between the variables time for learning mathematics with ICT and faculty. But, the relationship between the variables time for learning mathematics with ICT and level was found to be significant, $\chi^2 (4, N = 240) = 13.771$, $p < 0.05$. Therefore, it concludes that, there is relationship between the variables time for learning mathematics with ICT and enrolled level of students. Also, the association between the variables time for learning mathematics with ICT and location was found to be significant, $\chi^2 (4, N = 240) = 18.590$, $p < 0.05$. This concludes that, there is positive association between the variables time for learning mathematics with ICT and location of students. The result revealed that time spent in learning mathematics with ICT tools dependent with their gender, and faculty they studied and independent with their study level and location of campuses.

Students' Practices on Learning Mathematics

Similarly, in another question that on the average, how much of your time spent on learning Mathematics?, The response of the students reported that among 240 sample students, 23 (9.6%) respondent spent 1 to 25% of their time to study mathematics using ICT tools, 121 (50.4%) respondent spent 26 to 50% of the time to study mathematics using ICT tools, 68 (28.3%) respondent spent 51 to 75% time to

study mathematics using ICT tools and 28 (11.7%) respondent spent 76 to 100% of their total time to study mathematics each day.

Figure 6. *Students' Engagement on Learning Mathematics*



The above figure shows that more than half of the respondents (50.4%) give 26 to 50% time to study mathematics each day. This indicates that most of the study time of students was devoted on learning mathematics. Due to less competent on technology, students and teachers spent more time to operate mathematical software. Likewise, due to low bandwidth internet and unstability of electricity the teaching learning cannot run smoothly. The view of teacher T₁₈ about the practices of ICT tools by their students' on the interview reported that;

Due to the lack of internet facilities in their home, students must go to their friends for joining online classes. The low bandwidth internet facility and lack of technical knowledge on teachers and students create problems to join online class and operate mathematical software properly.

As the remarks expressed by my participant what I inferred that the there is necessity of proper learning environment with free internet facility and necessary mathematical software for students and proper training for teachers to conduct ICT

integrated classes. Although, some of the institutions have good access in using technology while teaching mathematics but the situation is different on other institutions. In this concern another participant T₃ share his view as;

We have equipped classrooms with free internet facilities in our campus and we can conduct classes from our own office if the physical presence of the students is not possible. I took many national and international classes and conduct many oral examinations from my home during the period of the pandemic. There is good access to ICT in our department and the classes were smoothly run during the pandemic through any one of the means like; MS Teams, Google meets, messenger group, and Zoom.

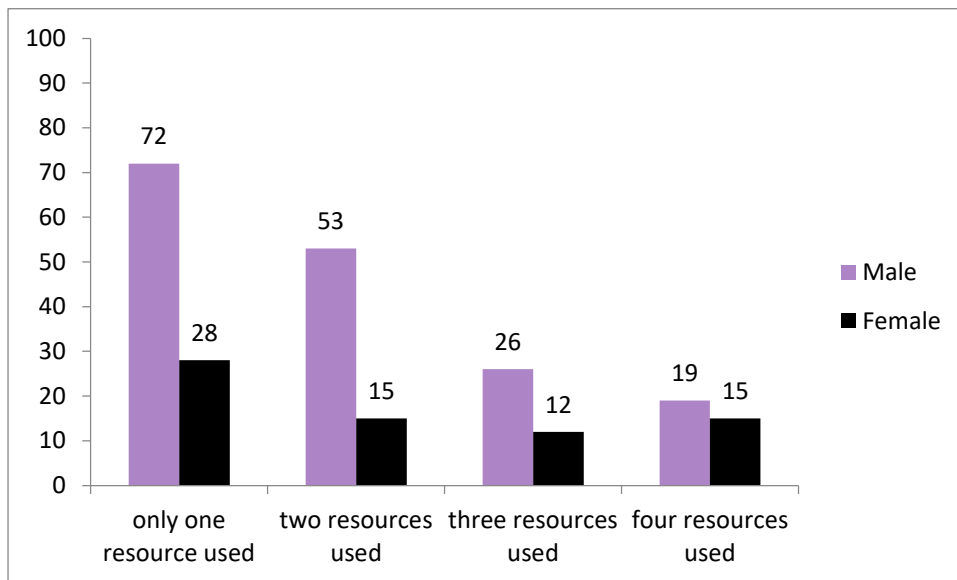
This result shows that the mathematics classes are quite resourceful and there is good access of ICT on constituent campuses of TU but there is lack of proper utilization of ICT tools. Teachers use varieties of platform to conduct online classes and students got opportunity to take their classes smoothly during the period of pandemic. There is opportunity to participate on resource classes of the expert and attain national and international conferences from own residence using ICT tools for the students. The technology integrated pedagogy is beneficial for students not only during the pandemic but also beyond it.

Students' Practices on Accessing Information/Resources

The way to search resources by the students do not depend on the campus location, enrolled level, gender, and discipline. On my question how do you mostly access the information/resources? There were four options: i). I use ICTs tools such as laptop, radio, mobile phone, TV, Tablet, CDs, and software tools such as You tube, Email, Wiki, Blog, Facebook, Google search, ii). I use library, iii). I consult with teachers, and iv). I consult with my friends. The response of students shows that out

of 240 respondents, 100(41.27%) respondents use only one resources to access the information or to get help, 68(28.3%) respondents use two resources to access the information or to get help, 38(15.8%) respondents use three resources to access the information or to get help and 34(14.2%) respondents use all four resources to access the information or to get help on their study.

Figure 7. *Accessing Resources for Learning*



The above figure indicates that most of our students (41.27%) use only one resource to access the information and search learning materials. The students use ICT tools and software to search reading materials and they consult with their teachers for resources to authenticate their knowledge. Only 14.2% of the respondents use all four options to access the information and for resources. In this concern the participant teacher T₅ expresses his view as;

ICT tools helps to develop searching habit on students. Some of our students search materials from different sources after my instruction. They develop global village and gives easy access to participate in different professional training and workshop through ICTs. They got chances to present their ideas worldwide due to technology. The students also search mathematical videos

on YouTube and got ideas to solve the mathematical problems by listening to the videos time and again.

The above view of teacher indicates that students mostly use YouTube and google search to access materials. Some of them search materials independently and some of them consult with their teachers. The recent development of ICT helps to expose the learners on global village and support for broaden their knowledge. To find the association between the number of resources used by the students for searching materials and student related variables like; gender, caste, level, discipline and location of the college, the chi square test of independence was performed and found the following result:

Table 7. *Number of Resources Used by Students for Searching Materials*

		Number of resources used for searching materials					
		One	Two	Three	Four	Total	χ^2
Gender	Male	42.35%	31.18%	15.29%	11.18%	170	5.514
	Female	40%	21.43%	17.14%	21.43%	70	
Faculty	Education	42.5%	29.17%	14.17%	14.16%	120	0.520
	Science	40.83%	27.5%	17.5%	14.17%	120	
Level	Bachelor	40%	31.67%	15.83%	12.5%	120	1.572
	Masters	43.33%	25%	15.83%	15.84%	120	
Location	Kathmandu valley	45%	24.17%	13.33%	17.5%	120	4.940
	Out of valley	38.34%	32.5%	18.33%	10.83%	120	

This result reveals that there is no association between the variables resource used for searching materials and enrolled level of students, location of college, gender and discipline. The data shows that 41.67% of the students use only one resource for

searching materials to learn mathematics, 28.33% students use two resources for searching materials, 15.83% students use three resources for searching materials, and 14.17% students use three resources for searching materials to learn mathematics. The finding of the data also reveals that master level students used more resources than bachelors level students and female students use more resources than male students to search materials in their learning process.

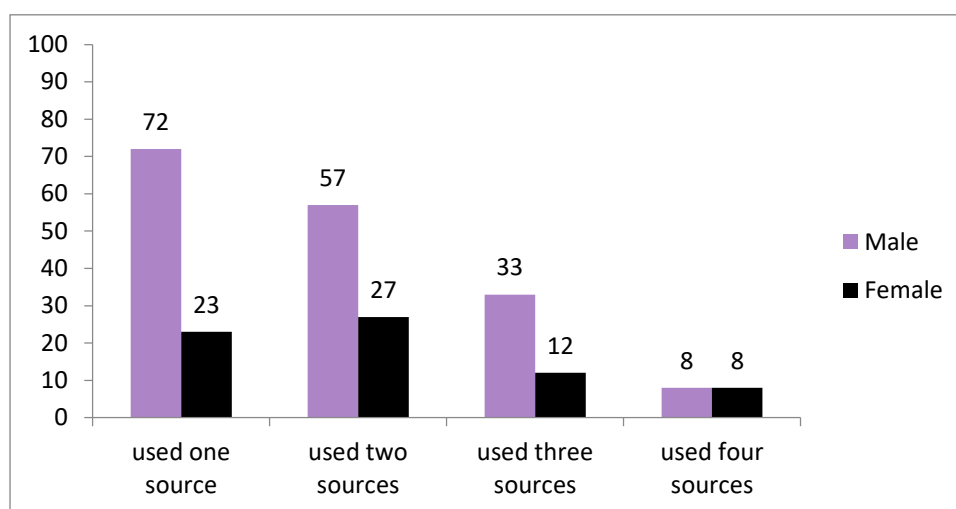
A chi-square test of independence was performed to examine the association between number of resources used for searching materials by the students with gender, caste, faculty, level and location of students. The association between the variables resource used for searching materials and gender was not found significant, $\chi^2 (3, N = 240) = 5.514, p > 0.05$. This concludes that, there is no association between the variables resources used for searching materials and gender. This informed that the way to search resources by the students do not depend on the gender of the students. Similarly, the association between the variables resource used for searching materials and faculty was not found significant, $\chi^2 (3, N = 240) = 0.520, p > 0.05$. This concludes that, there is no association between the variables resource used for searching materials and faculty. This result shows that the way to search resources by the students do not depend on the faculty of the students. Also, the association between the variables resource used for searching materials and level was not found to be significant, $\chi^2 (3, N = 240) = 1.572, p > 0.05$. It is concluded that, there is no association between the variables resource used for searching materials and level of students. Again, the association between the variables resource used for searching materials and location was not significant, $\chi^2 (3, N = 240) = 4.940, p > 0.05$. Therefore, it is concluded that, there is no association between the variables resource used for

searching materials and location of students. This informed that the way to search resources by the students do not depend on the campus location of the students.

Students' Practices for Accessing Assignment or Task

The resources used by the students to search materials submitting their assignment do not depend on the campus location, the students' enrollment level, their gender, and discipline. In my concern how and where do you find textbook related resources, assignments, or tasks? There are four options: i). I find them in LMS or while searching using ICTs, ii). I find them in the library, iii). I note down when our teacher informs them in the classroom and iv). I consult my friends for such things. The response of the respondents shows that out of 240 respondents, 95(39.6%) respondents use only one source to find textbook related resources, assignments, or tasks, 84(35%) respondents use two sources to find textbook related resources, assignments, or tasks, 45(18.8%) respondents use three sources to find textbook related resources, assignments, or tasks and 34(14.2%) respondents use four source to find textbook related resources, assignments, or tasks on their study.

Figure 8. *Source of Accessing Resources/Assignment*



The above figure indicates that nearly 40% students use only one method to find textbook related resources, assignment or task. Only 14.2% students use all

options (all 4 methods) to find learning resources and related information. This table also informed that due to poor knowledge on technology, students use less resources. In this concern one of my participant teacher T₁₅ express his view as: “Internet problems, geographical difficulties, lack of proper devices, less competent on ICT, improper physical environment and lack of competent administrative manpower our students have not access on proper resources”. The view of teacher indicate that our students do not have access on proper device to use technology and we have not provision of free e-library facility for all students to search their resources in the absence of their teachers. They have no proper internet and electricity facility for the students from remote area of Nepal even to join their online classes. To find the relationship between the number of sources used by the students for searching resources assignment/task and student related variables like; gender, caste, level, discipline and location of college, the chi-square test of independence was used

Table 8. *Sources Used by Students for Resources, Assignment/task*

		Number of sources used to find resources, assignment/task				Total	χ^2
		Using one source	Using two sources	Using three sources	Four Sources		
Gender	Male	42.35%	33.53%	19.41%	4.7%	170	4.987
	Female	32.86%	38.57%	17.14%	11.43%	70	
Faculty	Education	41.66%	33.33%	17.5%	7.5%	120	0.904
	Science	37.5%	36.67%	20%	5.83%	120	
Level	Bachelor	45%	32.5%	15.83%	6.66%	120	3.296
	Masters	34.17%	37.5%	21.66%	6.66%	120	
Location	Kathmandu	44.16%	30%	20%	5.84 %	120	3.438
	Out of valley	35%	40%	17.5%	7.5%	120	

The above table inform that there is no association between the variables; number of sources used to find resources, assignment/task and location of students, their enrollment level, gender and discipline. This informed that 11.43% female students use four sources where as only 4.7% male students use four sources for searching learning resources, assignment. This conclude that female students use more resources than male to find learning resources and for submitting their assignment. The total of 95 students use only one source to find resources, assignment/task to learn mathematics, 84 students use two sources to find resources, assignment/task to learn mathematics, 45 students use three sources to find resources, assignment/task to learn mathematics, and 34 students use three sources to find resources, assignment/task to learn mathematics.

A chi-square test of independence was performed to examine the association between number of sources used to find resources, assignment/task to learn mathematics by the students with Gender, caste, faculty, level and location of students. The relation between the variables number of sources used to find resources, assignment/task and gender was not found to be significant, $\chi^2 (3, N = 240) = 4.987$, $p > 0.05$. This result informed that, there is no association between the variables; sources used to find resources, assignment/task and Gender. This informed that the gender of the students does not effect the use of sources in their pedagogical process and there is equal access for sources for boys and girls.

Similarly, the association between the variables number of sources used to find resources, assignment/task and faculty was not found to be significant, $\chi^2 (3, N = 240) = 0.904$, $p > 0.05$. The result concludes that, there is no association between the variables number of sources used to find resources, assignment/task and faculty i.e. the way to using various resources by the students do not depend on the discipline

choose by the students. Also, the association between the variables number of sources used to find resources, assignment/task and level was not found significant, $\chi^2 (3, N = 240) = 3.296, p > 0.05$. It is concluded that, there is no association between the variable number of sources used to find resources, assignment/task and level of students i.e. the way to using various resources by the students do not depend on the student's enrollment level. Again, the association between the variables number of sources used to find resources, assignment/task and location was not found to be significant, $\chi^2 (3, N = 240) = 3.438, p > 0.05$. This concludes, there is no association between the variables; number of sources used to find resources, assignment/task and location of students i.e. the way to used different resources by the students to search materials do not depend on the campus location.

Perceptions of Students towards the Practices of ICTIP

The perception of students towards the implementations of ICTIP was found on three different variables input, implementations and output. There are five constructs: Human resource, infrastructure, digital resources, academic environment, curriculum integration on input, six constructs: Regularity, management, pedagogical process, intra and inter communication, opportunity and challenge, assessment and evaluation on implementations and six constructs: Student achievement, shift in pedagogy, outcome in society, change on attitude, promoting equity, pedagogical transformation on output of ICTIP. The weighted mean was used to find the positiveness of students' perceptions on each statement. The perception of students towards the practice of ICT integrated pedagogy was collected using five-point Likert scale. On the basis of weighted mean and standard deviation it was decided the students have positive or negative perceptions towards the practices ICTIP by their teachers in teaching mathematics. When the mean score of the perceptions of students

is greater than the median (3), they have positive perceptions and less than this was considered as negative perceptions.

Perceptions of Students towards the Input of ICTIP

There is positive perceptions of students' on the input, implementations, and output of ICT integrated pedagogical practices in higher education mathematics. The analysis of average perceptions obtained by the group of students was done on the basis of the median of scale value. When the mean score of the perceptions of students is greater than the median (3), they have positive perceptions and less than this was considered as negative perceptions. The perception of students was analyzed on the basis of input of human resource, infrastructure, digital resources, academic environment and curriculum integration to lunch ICTIP in their mathematics learning separately.

Table 9. *Perception of Students on Input of Infrastructure*

Statements	Weighted Mean	Standard Deviation
We have equipped classroom with sufficient spaces and fixed multimedia projector	4.14	0.640
Our institution develops ICT lab with sufficient computers	3.27	0.935
Technical support from administration to develop ICT friendly environment is necessary	4.23	0.528
Our institution provides necessary materials to integrate ICT in learning mathematics	3.45	1.224

Analyzing the perceptions of students, it was found that the average perception of students on the input of infrastructure was found 3.77. This shows that the students have positive perceptions towards the input of infrastructure. This perception of students informed that there is consistency between the perceptions of students about the input of infrastructure by their institutions. Students agreed on the statement ‘We have equipped classroom with sufficient spaces and fixed multimedia projector’ with mean value 4.14. Likewise, some of the campuses develop ICT lab and necessary environment to integrate ICT in learning mathematics. Most of the sample students strongly agreed on the statement ‘Technical support from administration to develop ICT friendly environment is necessary’ with mean score 4.23. This concludes that the technical support is necessary for the students to integrate ICT in learning mathematics due to unfamiliarity on technology. Supporting on this view of students one of my participant teacher T₁₃ expressed his view as;

In the previous days, we face technical problems to conduct the online class and there is a problem joining students on ICT devices. Due to the lack of proper devices and lack of TCT knowledge, some of our students are unable to join the online class on the pandemic period and they fail to practice on their homes as well.

The remarks expressed by the participant teacher informed the necessity of technical support for some teachers and students to integrate ICT on teaching learning process. Self-practices of students is not effective due to lack of proper device and technical knowledge. This conclude that most of the constituent campuses of TU are well equipped for integrating ICT on teaching learning process.

Table 10. *Perceptions of Students for Input of Human Resources*

Statements	Weighted	Standard
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	Mean	Deviation
There is availability of experienced teachers to use ICT tools and techniques, but we are not skilled in ICT	3.27	1.162
Teachers feel more stressed but responsible and accountable to students teaching and learning through ICT integrated pedagogy (ICTIP)	3.91	0.750
Our teachers are competent to organize and manage students' learning tasks through ICTs.	3.41	0.796
There is lack of technical support regarding ICT integration	4.18	0.958
ICT will upgrade teacher's role making it more substantial	3.68	1.086

The perception of students was collected using five statements related to human resources. Analyzing the average perceptions, it was found that the average perception of students on the input of human resources was found 3.69. This shows that the students have positive perceptions towards the input of human resources. The standard deviation of each statement shows that there is consistency between the perceptions of students on the input of human resources. This also informed that ICT upgrade teacher's role and they feel more stressed but responsible and accountable to students teaching and learning through ICTIP. The average perception of the students on the statement 'There is lack of technical support regarding ICT integration' is 4.18. This concludes that the technical support regarding the integration of ICT is not sufficient for students. The perceptions of students also informed that teachers were able to integrate ICT into their pedagogical practices and manage student's learning task through ICTs, but students felt some problems on it. The input of proper human

resources gradually improve teaching learning process that helps to increase achievement of the students.

Table 11. *Perceptions of Students on Input of Digital Resources*

Statements	Weighted Mean	Standard Deviation
We can use sufficient digital resources (i.e. smart board, e-library, mathematical software) in our college	2.82	1.181
High quality e-content creation and internet facility is available for students and teachers in our college	2.82	1.097
Our university develop a versatile and easy affordable digital device at the earliest	2.82	0.958

The above table reveals that the average perception of students on the input of digital resources was found 2.82. This shows that the students have negative perceptions towards the input of digital resources and conclude that the students are not satisfied on the availability of digital resources in their institutions. The view of students and my observation on the field revealed that our university does not develop a versatile and easy affordable digital device and there is no high-quality e-content creation and internet facility on most of the institutions. Supporting this view, the participant teacher T₆ say;

We have a lack of our own platform to lunch online classes. University must provide free devices and software facilities for teachers to make the class effective. The University authority is not serious to develop its own app and we use the app develop by others even though it has such manpower and resources.

The view of teacher informed that to make the teaching learning effective, the related institution needs to develop own online application and easy affordable digital device. Beside this, the university authority must be serious towards the effective implementations of ICT integrated pedagogy. The students actively engaged in learning if the classrooms are resourceful and students learn mathematics themselves in their home if we can provide mathematical software needed by the students.

Table 12. *Perceptions of Students on Input of Academic Environment*

Statements	Weighted Mean	Standard Deviation
There is peaceful and lovely environment with co-operative teachers and staffs in our college	4.00	0.976
There is provision of regular and interactive classes with resource materials for students	3.59	0.959
We feel proud to our institution for student friendly environment and rich library facility	3.59	1.008

The analysis of average perceptions obtained by the group of students was done on the basis of the median of scale value. The above table reveals that the average perception of students on the input of academic environment was found 3.73. This shows that the students have positive perceptions towards the input of academic environment. This concludes that the regularity of the students in the classroom and participation increases after the implementation of ICTIP due to students' friendly environment on their institution and co-operative teachers in mathematics discipline. The view of teacher is similar with the students that the regularity of students

increases after lunching online class during pandemic. In this regard, the teacher T₁₀ expressed his view as;

The classroom participation of students' increases due to the use of ICTs in class and students are more active and interactive in such classes. I feel all students benefited from online classes because the students were not interested to join their physical classes after the pandemic. The regularity of students and teachers on online classes was more than in physical classes in the context of our campus.

The above reflection of the teacher revealed that the students were benefited from the ICT integrated classes because the regularity and classroom participation of students increases and becoming more active and interactive in such classes. In this regards, Orlando and Attard (2016) have also mentioned that “technology integration is not a one size fits all approach”, rather it should be “to create different sizes fits for different approaches/diverse learners”. The technology integrated instruction is effectively applicable on diverse classes with students of different ability. ICT made possible to lunch class during pandemic using different online platform. After implementing ICTIP, the classes were regular and interactive with resource materials.

Table 13. *Perceptions of Students on Input of Curriculum Integration*

Statements	Weighted Mean	Standard Deviation
We can easily use ICTIP on various content of mathematics	3.41	0.959
Authority were not interested to develop ICT based curriculum	3.05	1.090
The curriculum is supportive for learning with ICTIP	3.55	1.057

Curriculum does not allow enough time to integrate	2.77	1.307
ICT in teaching		

The perception of students was collected using five-point Likert scale with distracter strongly agrees, agree, undecided, disagree and strongly disagree. The above table reveals that the average perception of students on the input of academic environment was found 3.195. This shows that the students have positive perceptions towards the input of ICT integrated curriculum but they are not satisfied enough with the possibility of ICT integration on some contents of mathematics. The weighted mean of the statement ‘Curriculum does not allow enough time to integrate ICT in teaching’ is 2.77. This is negative statement, so it reveals that the present curriculum is not barrier to integrate ICT on mathematics teaching.

This perception of students also shows that there is various content of mathematics on bachelors and master’s level where we can use different ICT tools and software to solve the problems. Supporting the view of students, the participant teacher T₅ say;

Even though, if teachers were committed to using ICT, we can use ICT tools and mathematical software to teach most of the courses of M Ed level like; Foundation of mathematics, Mathematical statistics, History of mathematics, DG, PG, Trends of mathematics education, Teaching undergraduate mathematics, Topology, and some contents of Algebra and Analysis.

The view of the teacher revealed that they can integrate ICTs and mathematical software to teach many contents of mathematics like; lgebra, analysis, DG, PG, statistics,... even though our curriculum is not completely ICT friendly. The

role of teacher is more important in the integration of technology in their pedagogical practices to teach mathematical contents of higher education.

Perception of Students towards the Implementations of ICTIP

On the basis of weighted mean and standard deviation, it was decided the students have positive or negative perceptions towards the implementation of ICTIP in their mathematics classroom. The following tables present the weighted mean and standard deviation of each of the statements on implementation of ICTIP.

Table 14. *Perception of Students on Regularity of Using ICTIP*

Statements	Weighted Mean	Standard Deviation
Our teachers use ICTIP in Mathematics class	4.36	0.790
The high-quality internet and necessary mathematical software facility are available for students	3.41	1.098
All the courses of mathematics are completed on allocated time frame integrating ICT	3.27	1.120

The students were found positive towards the implementation of ICT in mathematics teaching. The perception of students for the regularity of using ICTIP by their teachers was collected using five-point Likert scale with distracter Always (you use them for more than 88% of your study time), Usually (you use them for 67% to 88% of your study time), Generally (you use them for 45% to 66% of your study time), Often (for 23% to 44% of your study time), and Rarely (for up to 22% of your study time). The result suggests that average perception of students on the implementation of regularity was found high (3.68). This value shows that the students have positive perceptions towards the regularity of class as well as internet

and software facility. Most of the students about 51% express their view that teachers generally use ICT mathematical software in teaching mathematics but they always use ICTIP in their teaching.

The perceptions of students also revealed that teachers completed the courses on allocated time frame integrating ICT. Regarding about the poor access of electricity and internet facility the student S₅ on FGD expresses his view as;

High quality internet facility, teachers with good knowledge of ICT, ICT tools, mathematical software and 24-hour electricity facility are required for effective implementations of ICTIP. We made a policy, curriculum, and infrastructure to apply ICTIP. It is better to manage for ICT lab effectively for the development of mathematics.

This view of students informed that we need good policy and ICT integrated curriculum for the effective implementations of ICTIP. The present curriculum of mathematics in bachelor and master's level in both Science and Education sdiscipline does not seems ICT friendly.

Table 15. *Perception of Students on the Management of Classroom*

Statements	Weighted Mean	Standard Deviation
ICT integrated pedagogy is impressive but cannot contribute substantially to teaching and learning in diverse classes	4.00	0.926
The classroom management of teachers is appreciable using ICTIP	3.77	0.752

The data of above table reveals that the average perception of students on the appropriate management of class by teachers was found to be 3.885. This shows that the students have positive perceptions towards the classroom management of teachers and the classroom management of teachers is appreciable using ICTIP. The result of the table informed that there is consistency between the perceptions of students with standard deviation between 0.75 to 0.92.

Table 16. *Perceptions of Students on Pedagogical Process*

Statements	Weighted Mean	Standard Deviation
The ICT integrated pedagogy would contribute to increase necessary competencies on students compare to the traditional approach	4.23	0.752
Teachers use ICT integrated pedagogy effectively in our mathematics classroom	3.68	0.945
The frequency of students' interactions increases through ICT integrated pedagogy	3.36	1.049
ICT integrated pedagogy provides a space where learning can take place independently that makes learning easier	3.55	1.057

The perception of students towards the pedagogical process adopted by their teachers using ICT tools in their classes are collected and analyze on the basis of the weighted mean. From the above table what I found that the average perception of students on the pedagogical process adopted by teachers using ICTIP was 3.71. This shows that the students have positive perceptions towards the pedagogical process adopted by teachers using ICTIP. The result also concluded that the ICT based

pedagogy adopted by the teacher in their classroom made the pedagogical process effective and fruitful. The practices of ICT based pedagogy in mathematics classroom helps to increase necessary competencies on students compare to the traditional approach by making the learning independent and easier.

Table 17. *Perceptions of Students on Intra and Inter Communication*

Statements	Weighted Mean	Standard Deviation
ICT integrated pedagogy makes communication more convenient	3.91	1.151
We participate in discussion, group work to utilize the ICT tools such as google docs, email, Facebook, Skype, Wiki with our teachers	4.09	0.868
ICT integrated pedagogy increases interaction and motivation on learning mathematics	3.86	1.037

The perception of students was collected using five-point Likert scale with distractors; Always, Usually, Generally, Often and Rarely. The above table informed that the average perception of students on the intra and inter communication practiced by their teachers using ICTs on their classroom was found 3.95. This shows that the students have positive perceptions towards the use of intra and inter communication by teachers on their classes using ICTs. The findings from above table concludes that different ICT tools made the classroom interaction more convenient. The sample students believe that ICT based pedagogical process increase their motivation towards learning.

Table 18. *Perceptions of Students on Assessment and Evaluation*

Statements	Weighted	Standard
	Mean	Deviation
We use different ICT tools and techniques to prepare project work, field work, seminar and assignments.	4.09	0.868
All the assignment and examinations were submitted on Moodle or email through online mode	4.05	0.999

The perception of students reveals that ICT tools students feel more comfortable to prepare their project works and assignments. The above table informed that the average perception of students on implementations of assessment and evaluation was found 4.07. This shows that the students have positive perceptions towards the implementation of assessment and evaluation by their teachers. Some of the sample students were able to submit their assignment on Moodle and rest of the students use personal email or messenger group to submit their projects.

Table 19. *Perceptions of Students on Opportunity and Challenges for ICTIP*

Statements	Weighted	Standard
	Mean	Deviation
There are several problems to implement ICT integrated pedagogy due to time constraints	3.73	1.077
There are challenges to implement the ICT integrated pedagogy	4.14	1.082

The teaching-learning in your campus are interrupted because of some technological problems	3.73	0.985
ICTIP is not affordable for students due to lack of financial or academic support from institution	2.23	1.066

Using five distractors viz. Always, Usually, Generally, Often and Rarely the perceptions of students were collected and analyzed. The above table informed that the average perception of students towards the opportunity and challenges of ICTIP was found 3.37. This shows that the students have positive perceptions towards different opportunity and challenges for implementing ICTIP on higher mathematics classes effectively. The statement 'ICTIP is not affordable for students due to lack of financial or academic support from institution' is found negatively perceived by students with mean value 2.23. This result shows that the devices constraints and poor internet facility to implement ICTIP is the major problems for the stakeholders. Even though, most of the constituent campuses of TU have free internet facility for students and teachers and some of them provide free device for teachers but it does not work properly. The anytime anywhere learning opportunity for the students is the major opportunity of technology based pedagogical practices.

Perceptions of Students towards the Output of ICTIP

The perceptions of the students' towards the practices of ICT based pedagogy by their teachers to teach higher level mathematics was analyzed on the basis of mean and standard deviation. The following tables present the weighted mean and standard deviation of each of the statements on output of ICTIP.

Table 20. *Perceptions of Students for Output on Achievement*

Statements	Weighted	Standard
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	Mean	Deviation
The average achievement of students increases after the implementation of ICTIP	4.00	0.816
Application of ICT has made my understanding conceptual	3.59	0.796
I believe that ICT integrated pedagogy contribute on students learning because it makes student active	3.14	1.125

The perceptions of students was analyzed on the basis of the median of scale value. When the mean score of the perceptions of students is greater than the median (3), they have positive perceptions and less than three was considered as negative perceptions. The above table informed that the average perception of students towards the achievement of students was found 3.58. This shows that the students have positive perceptions towards the achievement of students on mathematics. The findings also concludes that after implementing ICT based instruction, the achievement of the students' increases because it helps on engaged and interactive learning with conceptual understanding. The findings from the data also reveals that the average achievement of the students increases after the practices of ICT based pedagogy in pedagogical practices of mathematics.

Table 21. *Perceptions of Students on Shift in Pedagogy through ICTIP*

Statements	Weighted Mean	Standard Deviation
There is a pedagogical shift from conventional teaching approach to ICT integrated pedagogy	3.86	0.990
I believe that ICT integrated pedagogy is useful for	4.00	1.024

teachers' as well as students to visualize abstract mathematical concepts clearly		
I believe that ICT integrated pedagogy can help students' critical thinking.	3.59	1.054

The above table informed that the average perception of students towards the role of ICT to shift in pedagogy was found 3.82. This concludes that the students have strong believed on ICT based pedagogy in mathematics teaching can be considered as the means of pedagogical transformation. The ICTs used by teachers in higher education mathematics classroom helps to visualize abstract concept of mathematics. The data also conclude that ICTIP helps students for critical thinking.

Table 22. *Perceptions of Students on Output in the Society through ICTIP*

Statements	Weighted Mean	Standard Deviation
The ICTIP is useful in higher mathematics classes because it will prevail in the future society	3.68	0.995
The ICT integrated pedagogy is useful for mathematical reasoning and concept development	3.68	0.894
I believe that ICT integrated pedagogy helps us to be critical in thinking	3.86	0.941

The perception of students about the role of ICT for the outcome in the society reveals that ICTIP is useful to prevail in the future society. The above table informed that the average perception of students towards the outcome in society was found 3.74. This shows that the students have positive perceptions towards the better

outcome in the society after implementing ICTIP in teaching learning process. The students also believed that ICT integrated pedagogy helps students to be critical in their thinking process.

Table 23. *Perceptions of Students on Impact on Policy through ICTIP*

Statements	Weighted Mean	Standard Deviation
I believe that textbooks' preferential role in education will be replaced by new media based on ICT	3.95	0.999
I believe that the teacher's role should be radically changed in future years because of ICT	4.05	0.785
ICT reduces teacher's role which may negatively affect in student's achievement.	2.82	1.181

The analysis of average perceptions obtained by the group of students was done on the basis of weighted mean. The above table informed that the average perception of students towards the impact on policy was found 3.61. This shows that the students have positive perceptions towards the impact on policy after the implementing ICTIP on mathematics teaching. The finding reveals that use of ICT on educational institution sinforce the concern authority to improve policy. The statements 'ICT reduces teacher's role which may negatively affect in student's achievement' have negative perception of students with mean value 2.82. This informs that the ICT does not reduce teacher's role but it have positive effect on the increment of student's achievement. The students strongly believe that after the implementation of ICT the role of mathematics classroom changes from lecturing to video/AI user and static figure of mathematics to dynamic figure.

Table 24. *Perceptions of Students on Change on Attitude through ICTIP*

Statements	Weighted Mean	Standard Deviation
I believe that the role of educational institutions will be radically changed in future years because of ICT	4.00	1.234
ICT integrated pedagogy produces new models for teaching and learning	4.09	0.526
ICT integrated pedagogy can be a best strategy for teaching and learning every content of mathematics	3.55	0.912

The perception of students' shows that ICT integrated pedagogy produces new model for teaching and learning. The data from above table informed that the average perception of students towards the change on attitude was found 3.88. This shows that the students have positive perceptions on each statement and found that the attitude of teachers and students changes by ICTIP. The respondents believes that as an emerging teaching model, ICT based pedagogy helps to transform the teaching strategies on educational institutions. The students have positive perceptions with the role of ICTIP to enhance their academic carrier. In this concern, S₉ say;

ICTIP is modern technology which can help us to study in a comfortable manner comparing to old pattern. Teaching learning activities is more effective, powerful, worldwide, comfort and easier using ICT tools. It makes easy to learn abstract contents of mathematics and understand these concepts with visualization. We are not feeling irritating to learn mathematics using ICTIP.

Based on this narrative of students about the importance of ICTIP, what I found that the attitude of students as well as teachers changes drastically and they were practiced in ICT tools in their pedagogical process. They also share their experiences that many abstract concept of mathematics can easily visualize using mathematical software and other ICT tools. They opened that teaching learning activities is more effective, easier and worldwide using ICT tools than the conventional method.

Table 25. *Perceptions of Students on Promoting Equity through ICTIP*

Statements	Weighted Mean	Standard Deviation
The ICTIP is helpful for applying culturally responsive skills of actively engaging students, using real world examples, assessing your learning other than tests, cooperative learning, and non-authoritarian styles of classroom management	3.86	0.774
For creating equitable learning opportunities in class, massive increase in meaning centered learning opportunity and critical focus on mathematics is needed.	3.68	0.780
Through ICT integrated pedagogy we students from different culture, different socioeconomic status and different level of learning can learn math equally	3.86	0.889
The ICTIP create equitable environment in higher mathematics class.	3.95	0.722

The data on above table informed that the average perception of students towards the promoting equity was found 3.84. This shows that the students have positive perceptions towards the role of ICTIP for promoting equity in mathematics classes. The perceptions of students informed that there is consistency between the perceptions of students with standard deviations between 0.722 and 0.889.

The statement ‘The ICTIP create equitable environment in higher mathematics class’ have mean value 3.95. This shows that the students were favor on the view that ICTIP create equitable learning environment in mathematics classes. They also have positive perceptions on the statement ‘Through ICT integrated pedagogy we students from different culture, different socioeconomic status and different level of learning can learn math equally’ with average value of 3.86. This indicates that the students from different culture, different socioeconomic status and different level of understanding equally benefitted from ICTIP.

Table 26. *Perceptions of Students on Pedagogical Transformation through ICTIP*

Statements	Weighted Mean	Standard Deviation
ICT helps us for easy access for learning mathematics in pandemic period of time.	4.18	0.795
ICTIP increases the students’ creativity and helps to develop meaning centered activities	3.77	0.922
There is critical focus on every contents of mathematics through ICTIP that makes the teaching learning process natural.	3.68	0.780
ICTIP make the teaching learning process meaningful and contextual.	3.86	0.941

The ICTIP is the best ways for pedagogical transformation in the digital era.	4.23	0.922
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The data present on above table shows that the average perception of students towards the pedagogical transformation was found 3.94. This shows the students have a positive believe that ICTIP helps for pedagogical transformation in teaching learning process. The finding of the data also informed that there is consistency between the perceptions of students with standard deviation between 0.780 and 0.941. The average perceptions of students on the statement ‘The ICTIP is the best way for pedagogical transformation in the digital era’ was found 4.23. This informed that there is a transformation in the pedagogical process due to ICTIP. Likewise, the students were also in favour on the statement ‘ICT helps us for easy access for learning mathematics in a pandemic period’ with average perception of 4.18. The teaching-learning process became possible during the pandemic due to ICTs. This is one of the transformations in the pedagogical process.

The data analysis result based on students’ questionnaire shows there is consistency between the perceptions of students on input, implementations and output of ICTIP. A total of 55 statements out of 61 statements have a weighted mean greater than 3 this indicates that students have positive perceptions towards the output of ICT-integrated pedagogy. To express a positive view about ICT integrated pedagogy, one of my student participants S_1 says;

ICTIP empower us to find new information by creating and allowing opportunities in math-based online platforms, websites and basically on YouTube which helps to enhance access to new information or resources. It helps us for easy access for learning mathematics in a pandemic period of

time. It increases creativity on us and helps to develop meaning centered activities and it makes the learning process meaningful. It creates an equitable learning environment and helps in producing new mode of pedagogy.

This characteristic as my participant announced that he has a strong belief in ICT integration pedagogy to empower their learning. In support of students' views, Ghosh, Hattangdi and Atonu (2007), and Becta (2014) say, there is greater collaboration between the pupils and technology as it helps to increase students' motivation towards the teaching. The pedagogical aspect is one of the purposes of introducing ICT in education where the pedagogical rationales are to utilize technology to enhance learning with flexible curriculum delivery system. Supporting the view of students one of my teacher participants T₅ expressed his view;

In my experience, the achievement of students increases after implementing ICTIP. If all the resources are available and use personal effort, then the teaching-learning activities must be far better than the conventional method of teaching. There are drastic changes in the teaching-learning process after implementing ICT-based pedagogy in teaching.

This view of teacher shows the importance of ICT-integrated pedagogy to increase student's academic achievement. The teaching learning process was drastically changed after the implementation of ICTIP in higher mathematics classes. It helps for the pedagogical transformation on teaching-learning process. The view of another teacher T₉ about the usefulness of mathematical software to visualize mathematical contents is; "I feel very difficult to generalize the abstract concept of mathematics like sine function, cosine function, and their curves teaching theoretically. But after the use of ICT tools and mathematics software like Mathematica, GeoGebra, and MATLAB, it is very easy to teach such concepts

practically with visualization.” This is one of the examples to show how ICTIP facilitate mathematics teaching and helps for visualizing concepts. Supporting the view of teachers, student participant S₁₅ on FGD say,

ICTIP plays a crucial role in teaching-learning activities of mathematics for facilitating communications, developing problem-solving skills, searching resources, increasing intellectual development of the learner, analyzing, managing and manipulating the large amount of data and developing communication skill to deliver contents effectively. During the pandemic, ICT make it easy to attain the class and submit our assignments via computer and mobile phone.

This narrative of students also informs the importance of ICTIP for facilitating teaching learning process during the COVID 19 pandemic and its role for personal development of learners. ICTs help for searching resources, developing problem solving skill on students and developing communication skill in the classroom. Mathematical software SPSS support students to analyze large amount of data in a short time period and the software GeoGebra helps to visualize three dimensional pictures in animated form. The ICT based pedagogy effectively implemented during COVID 19 pandemic.

Comparison of Students' Perceptions

There is no significant difference between the perception of students towards the practices of ICTIP in higher mathematics classes regarding the location of their campuses, gender, discipline, and their enrollment level. The total of 240 sample students selected from 18 different constituent campuses of TU from different location, different level and different gender were involved on data collection process. The perception of students was compared using t test at 0.05 alpha levels. The

perceptions of students about the practices of ICTIP was compared based on caste, gender, location, level and discipline of the students. The following table presents the comparative analysis of the obtained data:

Table 27. *Students Perceptions based on Gender, Discipline, Level and Location*

Group	N	Mean	SD	t	P value
Male	170	235.78	22.85	-0.024	0.981
Female	70	235.85	22.12		
Education	120	233.16	23.85	-1.82	0.070
Science	120	238.45	21.03		
Bachelors	120	236.75	23.86	0.648	0.518
Masters	120	234.86	21.32		
Within Kathmandu valley	120	236.01	22.22	0.14	0.889
Out of valley	120	235.60	23.06		

The above table informed that the perceptions of male and female students about the practices of ICTIP were not found significant, $t = -0.024$, $p > 0.05$. Therefore, it is concluded that the perceptions of students about the practice of ICTIP by their teacher in higher mathematics classes do not differ by their gender. Likewise, the difference on the perception of students between education and science faculty was not found significant, $t = -1.82$, $p > 0.05$. This concludes that the perception of students towards the practices of ICTIP in higher mathematics classes does not differ significantly with their discipline. Again, the difference between the perceptions of students enrolled on bachelors and master's level was not found significant, $t = 0.648$, $p > 0.05$. This concluded that, there is no significant difference between the

perceptions of students with their level of learning towards the practices of ICTIP in higher mathematics classes. Similarly, the difference on the perception of students on the campuses of Kathmandu valley and out of Kathmandu valley was not found significant, $t = 0.14$, $p > 0.05$. This concluded that, there is no significant difference between the perception of students towards the practices of ICTIP in higher mathematics classes with the location of their campuses.

Comparison of Students Perceptions based on Input, Implementations and Output

The perception of students was compared based on input, implementations and output of the practices of ICTIP using one-way ANOVA. The following table presents the comparative analysis of the obtained data:

Table 28. *Students Perceptions on Input, Implementations and Output of ICTIP*

		Df	Mean Square	F	P value
Input	Between Groups	82	145.758	5.672	.000
	Within Groups	157	25.696		
	Total	239			
Implementation	Between Groups	82	185.413	8.234	.000
	Within Groups	157	22.518		
	Total	239			
Output	Between Groups	82	277.501	8.346	.000
	Within Groups	157	33.251		
	Total	239			

The data presents on above table informed that the p value in each cases is less than 0.05. The result concludes that there is significant difference between the

perceptions of students' towards the different constructs of input implementations and output of ICTIP in higher education mathematics classes. This result informed that the perceptions of students differ significantly on the input of infrastructure, human resource, digital resource, and integration of ICT in mathematics curriculum. Likewise, the perception of students differ significantly on the implementations of and output of ICTIP on constituent campuses of TU was not satisfactory as the input on ICT facility. Likewise, the output was not so satisfactory as input and implementations on pedagogical process, inter and intra communication, assessment and evaluation. The perceptions of students' differ on the role of ICTIP for promoting equity, pedagogical transformation, outcome in the society and students achievement.

Comparison of Boys and Girls Perceptions on Different Constructs of Input on ICTIP

There is no significant difference between the perception of boys and girls on the input of ICT resources. The perception of male and female students was compared based on different constructs of input on ICTIP using t test. The following table presents the comparative analysis of the obtained data:

Table 29 *Students Perceptions on Different Constructs of Input on ICTIP Genderwise*

Gender		N	Mean	SD	t	P value
Infra.	Male	170	14.941	2.199	.903	.367
	Female	70	14.643	2.610		
Hum. Res.	Male	170	19.159	2.275	-1.157	.248
	Female	70	19.528	2.185		
Dig. Res.	Male	170	9.565	2.624	1.722	.086
	Female	70	8.914	2.744		

Aca. Env.	Male	170	11.435	1.884	-.711	.478
	Female	70	11.629	1.987		
Cur. Int.	Male	170	14.288	2.552	.125	.901
	Female	70	14.243	2.556		

Note: Dig. Res. = Digital Resources; Aca. Env. = Academic Environment; Cur. Int.=

Curriculum Integration; Infra.= Infrastructure; Hum. Res.= Human Resources

The data presents on above table informed that the p value in all cases is found greater than 0.05. This concludes that there is no significant difference between the perceptions of boys and girls towards input of digital resources, input of human resources, input of academic environment, input on infrastructure and integration of ICT in curriculum for delivering mathematical contents of higher level. This conclude that there is no variations on input of digital resources on different constituent campuses of TU. But, some sample campuses like University Campus, Kirtipur, Thakur Ram Campus have good digital resources than other campuses. Likewise, there is variability on the input of human resources and infrastructure on different constituent campuses of TU as well.

Comparison of Boys and Girls Perceptions on Different Constructs of Implementations of ICTIP

There is no significant difference between the perception of boys and girls on the implementations of ICTIP. The perception of male and female students was compared based on different constructs of implementations of ICTIP using t test. The following table presents the comparative analysis of the obtained data:

Table 30. *Students Perceptions on Different Constructs on Implementations of ICTIP**Genderwise*

	Gender	N	Mean	SD	T	P value
Reg.	Male	170	10.32	2.73	1.366	.173
	Female	70	9.78	2.878		
Mgmt.	Male	170	7.76	1.237	-.701	.484
	Female	70	7.88	1.161		
Ped. Pro.	Male	170	15.56	2.199	-.232	.817
	Female	70	15.64	2.740		
Intr. & Inte. Com.	Male	170	11.98	2.155	-.956	.340
	Female	70	12.27	2.064		
Ass. & Eva.	Male	170	7.42	1.763	-.306	.760
	Female	70	7.50	1.742		
Opp. & Ch.	Male	170	15.63	2.815	-.709	.479
	Female	70	15.90	2.100		

Note: Reg. = Regularity; Mgmt. = Management; Ped. Pro. = Pedagogical Process;

Intr. & Inte. Com. = Intra and Inter Communication; Ass. & Eva. = Assessment and

Evaluation; Opp. & Ch. = Opportunity and Challenges

The data on above table informed that the p value in each case is greater than 0.05 this conclude that there is no significant difference between the perception of boys and girls towards the regularity of classes, management of teachers and other resources and pedagogical process to implement ICTIP on higher mathematics classes. Likewise, there is no gender specific difference between the perceptions towards the opportunity and challenges of ICTIP, assessment and evaluation process and inter and intra communication on their institutions.

Comparison of Boys and Girls Perceptions on Different Constructs on Output of ICTIP

There is no significant difference between the perception of boys and girls on the output of ICT integrated pedagogical practices. The perceptions of male and female students was compared based on different constructs on output of ICTIP using t test. The following table presents the comparative analysis of the obtained data:

Table 31. *Students Perceptions on Different Constructs of Output of ICTIP*

	Gender	N	Mean	SD	T	P value
Std. Ach.	Male	170	12.34	1.869	1.086	.278
	Female	70	12.05	1.903		
Sif. Ped.	Male	170	12.24	1.743	-1.889	.060
	Female	70	12.71	1.737		
Out. Soc.	Male	170	12.18	1.801	-.870	.385
	Female	70	12.41	1.899		
Imp. Pol.	Male	170	11.48	2.176	.458	.648
	Female	70	11.34	2.070		
Cha. Att.	Male	170	12.44	1.706	.905	.366
	Female	70	12.21	1.903		
Prom. Equi.	Male	170	16.19	2.384	-.425	.671
	Female	70	16.33	1.791		
Ped. Tran.	Male	170	20.80	2.785	-.111	.912
	Female	70	20.84	2.534		

Note: Std. Ach. = Student Achievement; Sif. Ped. = Shift in Pedagogy; Out. Soc. = Outcome in the Society; Imp. Pol. = Implementing Policy; Cha. Att. = Change in Attitude; Prom. Equi. = Promoting Equity; Ped. Tran. = Pedagogical Transformation

The result based on above table informed that the p value on outcome in the society and promoting equity after the practices of ICTIP are greater than 0.05. This concludes that there is no significant difference between the perception of boys and girls towards the outcome in the society and equity promotion after the implementation of ICTIP in teaching mathematics. The p value on the output of students' achievement, shift in pedagogy, impact on policy, change on attitude and pedagogical transformation due to ICTIP are greater than 0.05. This concludes that there is no significant difference between the perceptions of students on the increment of students' achievement, shift in pedagogy, impact on policy, change on attitude and pedagogical transformation due to the implement ICTIP on higher mathematics classes.

Comparison of Students' Perceptions on General Practices for ICTIP

The perception of students was compared based on different constructs on output of ICTIP using one-way ANOVA. The following table presents the comparative analysis of the obtained data:

Table 32. *Students Perceptions on General Practices of Using ICT*

		Sum of	Df	Mean	F	Sig.
		Squares		Square		
	Between Groups	134.996	233	.579	.993	.578
Number of ICT tools used	Within Groups	3.500	6	.583		
	Total	138.496	239			
Number of hours spent in	Between Groups	266.933	233	1.146	.625	.852

learning	Within Groups	11.000	6	1.833		
	Total	277.933	239			
Number of hours spent for Mathematics	Between Groups	156.996	233	.674	1.155	.479
	Within Groups	3.500	6	.583		
	Total	160.496	239			
How do you assess the resource	Between Groups	265.850	233	1.141	0.856	.676
	Within Groups	8.000	6	1.333		
	Total	273.850	239			
Number of sources use to access resources, assignment	Between Groups	195.150	233	0.838	0.670	.819
	Within Groups	7.500	6	1.250		
	Total	202.650	239			

The data on above table informed that the p value on each case on the availability of resources, general practices of learning mathematics using ICT, sources used for assessing resources and time spent by students on learning mathematics using ICTs is greater than 0.05. This concludes that there is no significant difference between the perceptions of students using up to three ICT tools, up to six ICT tools, up to nine ICT tools and more than nine ICT tools to learn mathematics. This means the perceptions of students do not differ as the number of ICT tools they use. This also informed that there is no significant difference between the perception of students who spent less than one hour, one to two hours, two to three hours, three to four hours and more than four hours learning mathematics each day. This result also concludes that the perceptions of students does not differ as the time they spent on learning mathematics using ICT tools. Likewise, there is no significant difference between the perception of students who use one resource, two resources, three resources and four

resources to access information, reading materials, and searching assignments or tasks in their mathematics learning. This result revealed that the students using a different number of resources used in their learning process have similar perceptions. This indicates that the perceptions of students does not change as the students use number of resources they use in their learning process. The number of ICT tools they use matter in the engagement of time but it does not change the attitude of students towards the practices of ICTIP by their teachers.

Relationship between the Perceptions of Students

The inter correlation between five constructs viz. digital resource, human resource, infrastructure, academic environment and curriculum integration related to input of ICTIP was calculated and the relationship between the constructs. The following table presents the inter correlations between the perception of students based on different constructs of input integrating ICT.

Table 33. *Relationship between the constructs of Input on ICTIP based on Students' Perceptions*

	Digital resources	Academic environment	Curriculum integration	Infrastructure	Human resource
Digital resources	1	.382	.431	.361	.226
Academic environment		1	.457	.497	.321
Curriculum integration			1	.402	.260
Infrastructure				1	.267
Human resource					1

The above table shows that there is a positive correlation between the perceptions of students based on different constructs related to input of ICTIP in higher mathematics classes. There is a high correlation in the perception of students between infrastructure and academic environment and there is a low correlation between human resources and digital resources. This relation shows that the academic environment of the institutions is directly related to the infrastructure of the related institutions.

Table 34. *Relationship between the Constructs of Implementations of ICTI based on Students' Perceptions*

	R	M	PP	IIC	OC	AE
R	1	.270	.342	.319	.244	.432
M		1	.452	.253	.273	.270
PP			1	.476	.329	.373
IIC				1	.438	.581
OC					1	.356
AE						1

Note: R= Regularity, M= management, IIC= Inter and Intra Communication, OC= Opportunity and challenge, AE= assessment and Evaluation.

The above table informed that there is a positive correlation between the perceptions of the students between different constructs of implementations of ICTIP in higher mathematics classes. There is a high correlation on the perception of students between assessment and evaluation and intra and inter-communication. Likewise, there is a low correlation between opportunity and challenges and regularity. This relation shows that the assessment and evaluation is directly related to the intra and inter-communication between the students and teachers.

Table 35. *Relationship between the constructs of Output of ICTIP based on Students' Perceptions*

	SA	SP	OS	IP	CA	PE	PT
SA	1	.641	.551	.359	.518	.525	.538
SP		1	.411	.349	.484	.512	.529
OS			1	.456	.456	.458	.497
IP				1	.452	.428	.364
CA					1	.732	.598
PE						1	.605
PT							1

Note: SA= Student achievement, SP= Shift in pedagogy, OS= Outcome in society, IP= Impact on policy, CA= Change on attitude, PE= Promoting equity, PT= Pedagogical transformation

The result of above table shows that there is a positive correlation between the perceptions of the students between different constructs of the output of ICTIP in higher mathematics classes. There is a high correlation in the perception of students between student achievement and shift in pedagogy. Again, there is low correlation between impact on policy and shift in pedagogy. This relation shows that the shift in pedagogy on teaching-learning process improve the achievement of students. The above result also shows that the high correlation exists between change on attitude and promoting equity. The positive attitude of teachers helps to promote equity on the classroom. Likewise, the pedagogical transformation is directly related to promoting equity in the classroom. The change on attitude of the teachers and students positively correlated with pedagogical transformation on the classroom.

The correlation between input for ICTIP, implementation of ICTIP in classes and output of ICTIP based on students perceptions is presented in the following table:

Table 36. *Perceptions of Students between the Relationship of Input, Implementations and Output of ICTIP*

Spearman's rho correlation	Input	Implementation	Output
Input	1	.536	.303
Implementation		1	.497
Output			1

The above table shows that there is positive correlation between the perceptions of students with input, implementation and output of ICTIP applied by the teachers to teach mathematics. There is high correlation between input and implementation of ICTIP and the correlation is low between input and output of ICTIP. This concludes that there is no good implementation of ICTIP as our input but the outcome of ICTIP as our input is little good on constituent campuses of TU.

Analysis of Regression Effect of Students' General Practices and Input on Output of ICTIP

The following table shows the multiple linear regression model to evaluate impact of different constructs of input on the output of ICT integrated pedagogical practices:

Table 37. *Analysis of Effect of Input on Output of ICTIP*

Model Summary				ANOVA		
Model	R	R ²	Adjusted R ²	SEE	F	P value
1	.217 ^a	.047	.043	10.584	11.706	.001 ^b
2	.281 ^b	.079	.071	10.427	10.146	.000 ^c

3	.295 ^c	.087	.075	10.404	13.436	.000 ^d
4	.382 ^d	.146	.131	10.082	10.044	.000 ^e
5	.421 ^e	.177	.159	9.920	10.055	.000 ^f

Dependent Variable: Output of ICTIP

- a. Predictors: (Constant), Human resource
- b. Predictors: (Constant), Human resource, Digital resource
- c. Predictors: (Constant), Human resource, Digital resource, Infrastructure
- d. Predictors: (Constant), Human resource, Digital resource, Infrastructure, Academic environment
- e. Predictors: (Constant), Human resource, Digital resource, Infrastructure Academic environment, Curriculum integration.

The table 37 illustrates that the ANOVA test for model 1 ($F=11.71$, $p=0.001$), model 2 ($F=10.15$, $p=0.000$), model 3 ($F=13.44$, $p=0.000$), model 4 ($F=10.04$, $p=0.000$), model 5 ($F=10.05$, $p=0.000$) were statistically significant and hence all five regression model fit for further analysis of regression effect of different constructs of input on output of ICTIP in higher mathematics classroom. R^2 for model 1 was found to be .047 which means that 4.7% of the variance in output of ICTIP can be predicted by the input of human resources as respond by the students. R^2 for model 2 was found to be 0.079 which which means that 7.9% of the variance in output of ICTIP can be explained by the combine effect of input on human resources and digital resources as respond by the students. Similarly, R^2 for model 3 was found to be 0.087 which which means that 8.7% of the variance in output of ICTIP can be explained by the combine effect of input on human resources, digital resources and infrastructure as respond by the students. R^2 for model 4 was found to be 0.146 which which means that 14.7% of the variance in output of ICTIP can be explained by the combine effect of input on

human resources, digital resources, infrastructure and academic environment as respond by the students. Likewise, R^2 for model 5 was found to be 0.177 which which means that 17.7% of the variance in output of ICTIP can be explained by the combine effect of input on human resources, digital resources, infrastructure, academic environment and ICT integrated curriculum as respond by the students.

Table 38. *Regression Effect of Input of ICTIP on Output- Calculation of Coefficient of Collinearity Statistics*

Model		Unstandardized		Standardized	t	P value
		Coefficients		Coefficients		
		B	SEE	Beta		
1	(Constant)	77.71	5.90		13.172	.000
	Human resource	1.04	.304	.217	3.421	.001
2	(Constant)	74.57	5.914		12.609	.000
	Human resource	.84	.308	.175	2.736	.007
	Digital resource	.74	.259	.184	2.869	.004
3	(Constant)	70.74	6.472		10.931	.000
	Human resource	.75	.313	.156	2.392	.018
	Digital resource	.61	.273	.152	2.262	.025
4	Infrastructure	.45	.317	.098	1.439	.151
	(Constant)	66.31	6.368		10.413	.000
	Human resource	.502	.310	.104	1.621	.106
	Digital resource	.370	.272	.091	1.360	.175
5	Infrastructure	-.060	.333	-.013	-.180	.857
	Academic environment	1.671	.414	.295	4.033	.000
	(Constant)	62.923	6.369		9.880	.000

Human resource	.424	.306	.088	1.384	.168
Digital resource	.148	.278	.037	.535	.593
Infrastructure	-.219	.332	-.047	-.661	.509
Academic environment	1.367	.420	.242	3.253	.001
Curriculum integration	.899	.304	.212	2.962	.003

The data on table 38 concludes one-unit increase in input on human resource significantly increase in the output of ICTIP by 1.04 units in model 1 when human resources was considered as a single predictor, $B= 1.04$, $p=0.001$. Likewise, when we combined with digital resources it predicts output of ICTIP significantly increased by 0.84 unit per unit increase in input of human resources as presented in model 2, $B= 0.842$, $p= 0.007$. Model 3 predict one unit increase on input of human resources increase output of ICTIP by 0.75, $B=0.75$, $p=0.018$.

Table 39. *Analysis of Effect of General Practices of ICT on students Perceptions towards ICTIP*

Model Summary					ANOVA	
Model	R	R ²	Adjusted R ²	Std. Error of Estimate	F	P value
1	.073 ^a	.005	.001	22.583	1.274	.260 ^b
2	.078 ^b	.006	-.002	22.623	.722	.487 ^c
3	.079 ^c	.006	-.006	22.669	.491	.689 ^d

Dependent Variable: Perception

- Predictors: (Constant), Number of hours spent in learning mathematics
- Predictors: (Constant), Number of hours spent in learning mathematics, Number of ICT tools used
- Predictors: (Constant), Number of hours spent in learning mathematics, Number of ICT tools used, and practice of assessing resource.

The data on table 39 illustrates that the ANOVA test for model 1 ($F=11.71$, $p=0.001$), model 2 ($F=10.15$, $p=0.000$), model 3 ($F=13.44$, $p=0.000$), model 4 ($F=10.04$, $p=0.000$), model 5 ($F=10.05$, $p=0.000$) were statistically significant and hence all five regression model fit for further analysis of regression effect of different constructs of input on output of ICTIP in higher mathematics classroom.

Table 40. *Regression Effect of General Practices of ICT on Perceptions of ICTIP-*

Calculation of Collinearity Statistics

Model		Unstandardized		Standardized	T	P value
		Coefficients		Coefficients		
		B	Std. Error	Beta		
1	Number of hours spent in learning mathematics	1.53	1.355	.073	1.128	.260
	(Constant)	233.43	4.449		52.468	.000
2	Number of hours spent in learning mathematics	1.57	1.362	.075	1.157	.248
	Number of ICT tools used	-.81	1.929	-.027	-.419	.676
3	(Constant)	233.83	4.979		46.965	.000
	Number of hours spent in learning mathematics	1.57	1.364	.075	1.153	.250
	Number of ICT tools used	-.68	2.043	-.023	-.336	.737
	Practices of accessing resources	-.31	1.684	-.013	-.183	.855

Dependent Variable: Perception

a. Predictors: (Constant), Number of hours used in learning mathematics

b. Predictors: (Constant), Number of hours spent in learning mathematics, Number of ICT tools used

c. Predictors: (Constant),) Number of hours spent in learning mathematics, Number of ICT tools used, Practices of accessing resources

The data on table 40 informed one-unit increase in number of hours spent in learning mathematics significantly increase in the perceptions of students by 1.53 units in model 1 when number of hours spent in learning mathematics was considered as a single predictor, $B= 1.53$, $p=0.26$. Likewise, when we combined with number of ICT tools used it predicts perceptions significantly increased by 1.57 unit increase in number of hours spent in learning mathematics as presented in model 2, $B= 1.57$, $p= 0.24$. Model 3 predict one unit increase on number of hours spent in learning mathematics increase the perceptions by 1.57, $B=1.57$, $p=0.25$. This result conclude that there is positive effect of students' general practices of ICT on the perceptions of students.

Table 41. *Linear Regression Model on Impact of Implementation on Output of ICTIP*

Model	Unstandardized	Standardized	P value
	Coefficients		
	B	Beta	
(Constant)	42.001		.000
Regularity	.204	.052	.378
Management	2.347	.263	.000
Pedagogical process	.826	.180	.006
Intra and inter communication	1.079	.212	.003
Assessment and evaluation	.267	.043	.525

The above table informed that there is a positive impact of regularity, management, pedagogical process, intra and inter communication, and assessment and evaluation on the output of ICTIP. The result conclude that the provision of class regularity, good classroom management, appropriate pedagogical process, regular intra and inter communication with students and regular assessment and evaluation results better output on students achievement. The result also shows there is significant impact of better management, ICT based pedagogical process and intra and inter communication in the output of ICTIP.

Chapter Five

Experiences of Teachers on the Practices of ICTIP

The chapter focuses on the analysis of the data collected from different sources of the study. The aim of the study is the analysis of the experiences of teachers and the perceptions of students towards the practices of ICT-integrated pedagogy in higher mathematics classes. The qualitative data were collected and analyzed using the general inductive method. The qualitative data through teacher interviews were collected based on the themes; access to technology, motivating factors, teachers' preparedness, teachers' strategies, creativity and collaboration, criticality and co-operation, change management and opportunity and challenges of the ICT integrated pedagogy. The interviews were audio recorded and then it was transcribed, translated, and coded for further analysis. The content analysis was adopted based on the assigned codes, basic themes, organizing themes and global themes in the text. Finally, the global themes were described in terms of the basic themes, organizing themes and codes given. The data triangulation was maintained through interviews, observation of mathematics class and FGD with students.

All the qualitative data obtained through teacher interviews and FGD with students were first entered on ATLAS.ti for the coding process. There were 391 quotations, 136 codes, 37 basic themes, 24 organizing themes and 14 Global themes in the data obtained from teachers' interviews. Also, there were 139 quotations, 50 codes, 23 basic themes, 16 organizing themes and 8 global themes on the data obtained through FGD with students about the practices of ICTIP in higher education mathematics classes. All the qualitative data were used to find the answer to the fifth and sixth research questions; how do mathematics teachers' experiences ICT integrated pedagogy in higher education mathematics classroom? What are the

opportunities and challenges to integrate ICT in pedagogical practices in higher education mathematics classroom?

This chapter has been organized in three sections; Section I discusses the experiences of teachers towards the practices of information and communication technology in their higher education mathematics classes, Section II discusses the role of ICTIP in promoting equity and helping for pedagogical transformation, and Section III discusses the opportunities and challenges to implement ICTIP into pedagogical practices.

Teachers' Experiences towards the Practices of ICTIP in Higher Education Mathematics Classes

The experiences of all 18 mathematics teachers' taught in 12 different constituent campuses of TU including education and science discipline about the practices of ICTIP were collected through in-depth interviews. Similarly, the perceptions of the 16 students' who participated in FGD were collected and analyzed in this section. The following global themes were developed based on qualitative data analysis:

ICT for Anytime Anywhere

ICT-integrated pedagogical practices have ensured anytime anywhere learning opportunities to students of higher level very effectively. This web-based learning space created a learning opportunity for the student beyond face-to-face and campus boundaries. In this study, students' and teachers' responses related to the code "anytime anywhere learning" is presented systematically. Anytime anywhere learning is a web-based learning space. In literature, it mentioned that the online and blended learning environment that university teachers practice these days may be helpful to connecting home, campus and other spaces anytime anywhere whenever required

(Downes, 2005). In this regard, my own experiences in day-to-day teaching at campus as a faculty, at Tribhuvan University is one of the examples in teaching mathematics.

These days, I prefer to use Moodle as a virtual learning environment and blended mode of instruction in my class. It have created flexible learning opportunities in my pedagogical process by utilizing online learning resources, time/activity, feedback /support, and assessment, both the teacher and student perspectives. Similar evidences are also shown in a literature (Kaplan & Haenlein, 2009).

Anytime and anywhere means pedagogical process extends beyond the classroom and traditional campus day. It was found that the students unable to join their face-to-face classes due to different circumstances were much benefited through online classes. Using the internet and digital devices; particularly mobile phones, the recorded classes of teachers helped them to learn. They further explored necessary materials available on Teams or Zoom or Moodle platforms anytime anywhere. The responses of teacher (T₁) related to ICT for anytime anywhere learning is; “The online learning platform like Moodle provided information access 24 hours time, it made Mathematics learning easier.” The view of the teacher informed that using Moodle, it is possible to conduct virtual teaching learning environment where interaction and discussion can happen not only between teachers and students but also between the students anytime anywhere. Similarly, Moodle use in higher mathematics education classes seems to be helpful for providing opportunity of virtual learning environment by integrating mathematical software like GeoGebra, Mathematica to visualize an abstract and proof-oriented mathematical contents. Supporting the view of teacher another participant teacher T₈ share his experience as; “I use Google Meet in teaching to share important classroom videos of experts and reference materials for

students so that students can download the materials they need”. Likewise, another teacher T₁₅ also agreed that use of ICTIP provides any time any where opportunity on learning. He said; “Students put their problems with teachers through a different medium at their comfortable time but there is a lack of proper devices and dedicated internet facilities in their homes”. The experiences of the teachers informed that using different learning platforms like; Zoom classroom, MS Teams, Messenger group, WhatsApp group, MOODLE, Google Meet, and other personal communication tools made students learn any time any-where. For example, using Moodle as Web-based teaching space, both teachers and students can work online anytime anywhere with an internet connection and can work in an offline context.

Any time any where learning gives the opportunity for students beyond physical classes and the students who were engage in their job benefitted from it. The experience of teacher T₁₁ in this context is; “The students’ share the recorded class in respective messenger groups in the absence of a particular subject teacher and discuss it on the group. They also share these videos with the absent students”. This view of teacher indicate that not only teacher, the students also, coopetate with their friends for learning. The practice of group work promotes the ICT based pedagogical practices. Supporting this view another teacher T₁₃ say; “I manage the alternative class at a convenient time for teachers and students”. This is an example of the flexibility of online classes, which provides good opportunity for job holder students to continue their education. In this regards, the participant teacher T₄ put his opinion as; “The absent students in physical /online classes have an opportunity to download the recorded class of the teachers and they have an opportunity to learn mathematics by listening to the recorded classes time and again from their comfort zone”. From this narratives of teacher what I informed that the blended mode of instruction provides

any one any time any where learning opportunity which is another benefit of ICTIP in higher education mathematics classes.

There were other similar answers in the teachers' responses. Among 18 respondents, twelve teachers reported that they allowed students to record their online classes and students can learn from the recorded class time and again to improve their conceptual understanding. In a similar study, Pilley has mentioned that technology helps students remain connected to tutors, peers and information through discussions, and video records in anywhere, anytime frame of access (Pilley, 2016). This shows that students got anytime anywhere learning opportunities through ICTIP. Online resources like video lessons and other digital resources help students to learn when they are in need. In addition, the teachers T₃, T₅, T₁₂ and T₁₆ have similar views,

We can conduct our class at our convenient time as per the request of job holder students. The students from remote areas also can participate such type of class easily beyond their office time that increased the regularity of students. The students from remote areas and students unable to join their class in the scheduled class routine also benefited when teachers conduct online classes of mathematics. Another major benefit of ICTIP is content permanency and sharing culture in their comfortable time and zone.

This conclude that ICT integrated pedagogy contributed for resourceful learning for anyone, anytime and anywhere with flexible and diverse learning opportunity. In this concern another participant T₂ said; "ICT helps students with easy access to learning materials and they have the opportunity to learn mathematics anytime and anywhere." The experiences of teachers informed that ICT tools help students to find learning resources easily at their convenient time and space.

Geographically diverse countries like Nepal are more benefitted from online classes.

Different ICT tools and learning platforms make students independent and creative. The online classes conducted by the teachers beyond office hours are also beneficial for the job holder students as they can learn in their comfortable time and zone. The findings of the study by Rosen and Nelson is similar as Web-based teaching is helpful to enhance teaching and learning hours beyond F2F and school/campus boundaries in the form of anytime anywhere learning space (Rosen & Nelson, 2008). This provision helps to increase the regularity of the students in their classes and the students can freely involve in learning.

ICT as a Motivating Factor

The use of ICT in learning mathematics makes students independent and motivated and for being creative and collaborative. Several factors motivate students and teachers to choose ICT tools for the educational process of a higher level. The first factor is the student's prior experience and the second general factor is interest in the subject to be studied. Interest has been considered mostly important for students majoring in computer-related subjects (Alexander et al., 2011). The students who enter higher education have more confidence in using technology than before. That's why ICT in learning mathematics increases students' interest and joy learning process (Tossavainen & Faarinen, 2019). This indicates that students were highly motivated towards ICT due to intrinsic motivation than extrinsic motivation. Supporting this view, the participant teacher T₅ in his interview says; "I am motivated to use ICT in my teaching profession due to its multiple uses. The important factors motivating me for using ICTIP are students' curiosity and active participation in their class". This narrative informed that using technology in teaching increases the curiosity of learner and actively participates on the class. This leads to the motivation of teacher to use ICTIP on their classes. There are eight quotations, six codes, four basic themes and

one global theme based on experience of teachers on ICT as a motivating factors have been presented in a couple of paragraphs.

The experiences of teachers about the multiple uses of ICT tools for mathematics learning indicate that in the education system, ICT and mathematics are inseparable disciplines and ICT-integrated pedagogy helps to make the learning permanent. Supporting this view one of my participant teachers T₉ says “Using ICT tools, students actively participated in mathematics classes because they learn mathematics differently and practically. It helps students and teachers to be exposed on the global village”. The experiences of teachers reveal that ICT motivates students to be independent and creative. Besides this, if teachers use ICT tools then students actively participate in classes and they learn mathematics differently and practically. In this concern the participant teacher T₂ says; “When we use mathematical software to visualize the mathematical concepts in higher mathematics classes, then the curiosity increases in students’ and the students develop conceptual understanding and are motivated toward learning.” This narrative of the teacher participant indicates that for the development of a conceptual understanding of mathematics and curiosity about learning, mathematical software has a crucial role. During the pandemic ICT plays very important role in educational system and made the teaching-learning process possible. ICTs help students with easy access on resources and expose the stakeholders to the global village.

This is the age of technology and an era of revolution in the field of teaching learning. In these days, ICT tools were mostly used on entertainment and to reduce unnecessary complications. In this concern, another participant teacher T₁₂ expressed his view as; “ICT helps teachers to give mathematical concepts clearly and it helps for permanent learning on students”. From this view of the teacher and my experiences

also conclude that the active participation of students on learning made the learning permanent and students engaged on their classroom activities if they got proper ICT tools. Even though some of the teachers and students in the mathematics classes have misconception of to use of technological tools in their classes for educational improvement, it helps to improve students' achievement. Describing the importance of ICT tools to learn mathematics effectively and ICTIP practiced by the teachers' one of my participant students S₇ in FGD expressed his view as;

ICTIP is useful for mathematical reasoning and concept development so it will prevail in the future society. ICTIP plays a positive role for accessing information/resources in higher mathematics study. The role of ICT Integrated Pedagogy is to provide the idea to search related websites, idea to search articles and textbooks as resources. For me, the ICTIP used by teachers in the class provides a guideline to develop the concept easily. When teachers are digitally literate and trained to use ICT, these approaches can lead to higher-order thinking skills, provide creative and individualized options for students to express their understandings, and encourage students better prepared to deal with ongoing technological change in society and the workplace. Most of the people think that ICT is very useful only in school level but it is also useful in higher level.

The above view of the student informed that ICTIP is very fruitful for conceptual understanding and helpful for developing mathematical reasoning. It makes students independent and motivated and for being creative and collaborative. ICTIP is not only effective on school level but equally effective on university level. Using different ICT tools and websites students can easily search the learning resources and authenticate their knowledge. It also encourages students better

prepared to deal with ongoing technological change in society and their personal workplace. So, ICT tools and techniques were used as motivating factors in the pedagogical process.

ICTIP for Creativity and Collaboration

Collaborative learning is a student-centred learning approach in which the learners learn together by being involved in problem-solving tasks. Collaborative learning needs a defined setting where the learners learn in a group with a high degree of interaction among the group members (Hoppe, 2007). In this research, I explored the participant' experiences towards the practices of ICTIP to promote collaborative activities and the nature of the collaborative tasks and activities they used in their classes. I also attempted to study how ICTIP helped the learners to be creative in learning and enhance their collaborative activities in teaching teaching-learning process. The responses of T₁ is, "ICTIP helped all the students with collaborative work and activated on learning. It provided an opportunity for interaction with friends that makes the learning process effective."

The view of the teacher informed that using different communication platforms like; messenger, viber, skype, whatsapp, and personal email students communicate with their friends about their learning materials. They also use zoom or Msteam for group work and experience sharing. Supporting the above view, another teacher T₁₁ share his view on interview as "Students seem very happy and interactive in discussions and share their problems with the group during the absence of teachers. They solve their problems through group work and collaboration". The narrative of the teacher present the self learning practice of students and collaboration between them. The collaboration not only confined between students using ICT tools but also between students and teachers. In this concern another participant teacher T₇ say;

“ICT helps collaboration between students-students, students-teachers, and teachers-teacher by sharing their experiences, problems, teaching strategies, necessary documents and innovative ideas whether they live in any country of the world”. This view of teacher informed me that in this digital era the teaching learning process not only limited on the campus permises. Use of ICT tool in education helps to connect the people of the world in a single platform easily and share their ideas. There is similar view of student S_3 about the importance of ICT tools “I can find everything that I want and get ideas where I feel confused using ICT tools. ICTP helped me in critical thinking and collaborative activities that encouraged me to work and learn with my friends”. This wiew of student and my own experience conclude that the advantages of the ICT-based classes are group learning, promoting collaboration and creativity.

The ICT integrated pedagogical practices in mathematics classes using mathematical software helps teacher to visualize abstract concepts of mathematics which is not possible to present in the physical class. In this concern the participant teacher T_{15} put his interview as “Our students present their skills very beautifully in their project work. The presentation of some students using GeoGebra and Mathematica software was a model for others”. The view of another teacher T_9 is similar with this view. He say; “There are some extraordinary students in each mathematics class who even help us to integrate ICT tools into classes. They presented their project work very nicely using ICT tools and software”. The students fromnew generation are skilled on ICT and they are creative, cooperative, interactive and collaborative in classes. The view of teacher taught in masters level is quite different than the teachers taught in bachelors level. The wiew of teacher T_2 taught in master level students is, “Our masters-level students were more active and

independent in their class rather than the bachelor's class. Students felt free in their presentations on online classes rather than physical classes". This view informed me that the students feel hesitate in physical classes present their project nicely without any hesitation on their online presentation. But within thir pair group students actively participate in discussion. Supporting above view of teacher one of the students S₅ on online FGD say; "There is a collaboration between us in mathematics class, especially in our project work preparation". Online class make students creative and cooperative. The folloving view of teacher T₁₂ is also in similar line. He opined; "Students seem curious and happy in online classes. They shared important reading materials with logical reasoning for solving abstract concepts using attractive PowerPoint". The above narratives of the participant students and teachers revealed that ICT-integrated pedagogy practised by mathematics teachers in their higher mathematics classes motivated students to be more engaged in learning with varieties of learning resources. The opinion of teacher T₁₈ seems similar; "Some of our students were able to sketch three-dimensional figures and present it in class easily. Students developed the habit of searching materials and class videos through given sites and learn themselves". The students were authenticate their learning themselves using free online resources on YouTube, google and other sources. Collaborative classroom learning with sharing experiences, developing innovative ideas and getting exposure for ideas sharing are the major benefits of integrating ICTs in learning. Also, T₆ opined, "The students of mathematics were more creative, regular, motivated, and curious in ICT class than I expected. They have active participation in their classes". All the participants were positive that ICTs could contribute a lot to collaborative works such as group/pair works, and project tasks. For conducting such collaborative

activities, they most often used ICT hardware tools like laptops/desktops and mobile phones.

Likewise, the students used ICT software tools such as Facebook, Skype, Messenger Group and Google Docs. In this concern, one of the students S₇ in FGD opined, “With the help of the ICT tools we can do our group work assignments and tasks very easily by discussing and working together”. Advocating the importance of ICT-integrated pedagogy for creativity and collaboration another students S₂ expressed his view in FGD as;

The major roles of ICTIP to enhance learning are; to change the way of learning, to be creative, to develop a self-learning environment, to make learning practicable using learning by searching and to solve problems quickly. Not only can it facilitate certain collaborative activities but it also can enable us work collaboratively even when we are located in different places and collaborating at different times. By using various ICT tools, it is easy and convenient for learning abstract concepts of mathematics.

The students opined that they could save their time and effort using the ICT tools in the collaborative group work activities. They could have discussions easily through video chat with their friends who lived far from them. If they had not used ICT tools it would take a long time to share their ideas, information, and resources with their friends. Supporting the view of students one of the participants teacher T₄ expressed his view as,

ICT helps for collaboration between students-students, students-teachers, and teachers-teachers by sharing their experiences, problems, strategies for teaching, necessary documents and innovative ideas whether they live in any country of the world. The students involved in sharing their ideas or materials

for doing the tasks. They utilized the ICT tools for preparation and submitted their assignment in time.

The view expressed by the teacher is what I found that the students felt more comfortable while interacting, communicating or discussing about their queries with their friends and their teachers physically as well as virtually. He also observed that the students, who hesitated in face-to-face communication, felt easy in communicate with the ICTs. The ICT tools helped them for sharing ideas and resources, for doing discussion, and for performing the tasks together in pairs and in groups. ICTIP enable the learner for communicate, interact, and exchange information, which are the basic components of collaborative activities. The experience of teacher informed that in preparing the project work and its presentation students demonstrate their creativity. About the role of ICTIP to increase creativity on students, teacher T₁₅ expresses his experiences as;

Creativity depends on the activity of students and teachers in mathematics classes. The creativity of students and teachers does not increase if they use ICT to present readymade materials on PowerPoint only. On the other, the creativity of students and teachers increases if we use ICT properly and made classroom discussions lively by using different software and animations to clarify abstract concepts of mathematics. Some students present their project work very nicely and show their creativity on their presentation. The creativity of the students' increases properly if we use students centered discussion and interactions in our classes.

The above narrative of teacher informed me that the proper use of ICT tools increases curiosity on students. The student centered discussion on class and the provision of project work made the students creative and self-regulated which helps to

increase achievement of students. The power-point presentation, simply as a slide show, kills the creativity of the students. More engagement on activity results the conceptual clarity and learning permanency on students.

The creativity and collaboration was found when observing the class. The class observed on March 19, 2021 was concerned with the use of ICTIP for collaboration and creativity of the students. The lesson of the day was Hypothesis Testing from the course Mathematical Statistics of M Ed first semester. After warming up the class, the teacher shared a video that highlighted the basic concepts that were important for the students to utilize hypothesis testing. Then, using powerpoint presentation, he explained and discussed the importance of hypothesis testing, the steps of hypothesis testing, level of significance, degree of freedom and type I and type II errors in hypothesis testing with examples. The students actively participated in watching the powerpoint and question-answer discussion initiated by the teacher. There was an active participation of the students and a good interaction between the teacher and the students as they had somehow understood the concept. Finally, the teacher gave them a group assignment. He divided the students into four groups and informed all students to prepare the answer individually first, then to share the answer to the group members and the class teacher as well. And, after that, the group needed to finalize the answer.

The class observations revealed that ICTIP was utilized by the teacher for making his presentation attractive, and resourceful. He exploited the ICT tools both in the preparation and presentation of the lesson. The students used ICTs for collecting resources, preparing the assignment and interacting with the group members. They also utilize interactive Media for sharing their progress while conducting the tasks or assignments as collaborative activities. Some of the students gave answers of the

teacher respectfully and the creativity of the students was clearly seen in the interaction. Collaborative learning can be facilitated by using ICT technologies including virtual classrooms, online discussion boards, and collaborative software. Under a social constructivist approach, students can collaborate, have group discussions on mathematical ideas, and solve problems as a group. This creates an atmosphere in which students create meaning by interacting with one another, sharing ideas, and expanding on one another's comprehension.

ICTIP is not Time-consuming

The ICT tools and mathematical software help to solve numerical problems quickly and make processes of delivering concepts comfortable. To teach higher mathematical content properly and within given time frame, a teacher needs proper planning and skill of using ICTIP. The general opinion of the people in the society shows that using ICT in teaching teaching-learning process is time-consuming. If the ICT teacher is less competent on technology then he/she faces many obstacles and technical problems in applying ICTIP. In this concern, one of the participant teachers T₁₄ expressed his experiences, “During the previous days of the pandemic when we started the online class, we faced many problems in conducting the class smoothly due to the lack of technical knowledge on ICT and proper training to conduct such classes.” This informed that the majority of the participant teachers begins the ICT integrated classes on mathematics during the COVID19 pandemic. They need ICT training to conduct online Classes and operate mathematical software. Supporting the above view, the quotation experienced by teacher T₂ related to time management through ICT is as follows:

In the previous days it takes more time to prepare classes through ICT but it makes the teaching process very easy from prepared documents at present.

Using ICT in teaching is a one-time time investment for preparation. We can complete our courses before the scheduled time using ICT.

This narrative of teacher informed that all of the mathematics teachers completed their course on time using ICTIP even though they needed more effort to prepare reading materials. Preparing materials using ICT is a one-time investment and it makes the teaching-learning process systematic and quick. In this concern, one of the participant T₅ put his view as;

We need proper planning and skill to make effective classes using ICTIP for teaching higher mathematical content. ICT saves time in case of solving numerical problems and is helpful in the process of delivering concepts. The teachers who were not familiar with ICT felt some problems on the online classes.

Using ICT integrated pedagogical process, different mathematics concepts can be generalize easily. The following view of teacher T₈ also support this finding. He expressed his view as; “ICT-based teaching helps me to generalize concepts like; limit, continuity, three-dimensional geometry, and binomial expansion... during a short period but I need three times more preparation for developing classroom materials for ICTIP. This experience of teacher reveals that most of the time of teacher devoted to develop digital learning materials. If teachers have less competencies on ICT, they need more time effort in the preparation phase.

Supporting the view of teacher another teacher T₁ shared his view as; “In my experience, using ICT is a new technique to develop innovative skills in the teaching-learning process for me. Even though, I completed the courses of 150 credit hours on 120 credit hours using ICT tools”. This narrative of teacher conclude that ICTIP is not time consuming teaching method but it make the the learning easy and quick. In

this regards the participant T₁₅ say; “Many problems of mathematics like; differentiation, integration, hypothesis testing, estimation, binomial expansion, projectivity, perspectivity... can be completed in a short time period using different ICT software and YouTube videos”.

The above view of teacher indicate that the use of technology is helpful to save time and meets a real need that teachers have. The mathematical software that helps teachers with numerical calculations within short time periods as well as teacher-student communication tools as an example for saving time. The benefit of using ICTIP in the classroom is obvious and teachers can reduce the amount of time wasted on administrative tasks that increase instruction time (Sharma et al., 2011). As the conclusion of Sharma et al, the participant teacher T₇ shared his experience as; “If the teachers were prepared properly before entering the class then it is easy to complete the course in time. I finished the course in time and did not need the extra effort in teaching using ICT”. The view of teachers and my own experience conclude that ICT integrated pedagogical practices in higher education mathematics classes is more benifital for students for their conceptual understanding and for teachers to make their teaching effective and student friendly. Teacher do not need extra effort to complete their course within the time frame using ICTIP.

ICT for Visualizing Abstract Concepts of Mathematics

Visualization is a special process of transforming construction, mental images, and representations. It helps to establish a connection between information about ideas, which are previously unknown and understandings which gradually develop. Visualization seems not only in the development of mathematical thoughts but also in the discovery of new relations between mathematical objects, as well as for giving

meaning to mathematical concepts and existing relationships between them (Yilmaz & Argun, 2018). It also presents the opportunity to decrease complexity in case sufficient information is available. Most of the research participants in this research agreed that technology helps to visualize abstract concepts of mathematics. The experience of teacher T₁₃ is

We are unable to generalize the abstract concept of mathematics like sine function, cosine function, and their curves teaching theoretically. But after the use of ICT tools and mathematics software like Mathematica, GeoGebra, and MATLAB, it is very easy to teach such concepts practically with visualization.

This view of the teacher informed that the mathematical software used by them in the class facilitates learning with visualization and conceptualization. The response of one of my respondent student S₁ related to the role of ICT for visualizing abstract concepts of mathematics on the FGD is; “Our classroom became more attractive and interesting due to ICT. I understand abstract mathematical concepts very well and clearly by using ICT-related software and YouTube videos”. This narrative of the students informed that as suggested by AR technology leads learner to deeper understanding and updated knowledge, particularly in the process of learning complex or abstract concepts of mathematics. The view of another participant S₁₂ is as;

ICTIP is a modern technology which can help us to study in a comfortable manner compared to old pattern. Teaching learning activities is more effective, powerful, worldwide, comfort and easier using ICT tools. ICT makes it easy to learn abstract contents of mathematics and understand these concepts with visualization.

The ICT tools and ICT based pedagogical process in mathematics classes is benefitted for conceptual understanding. In this concern the teacher participant T₂ opined “ICT makes clear understanding on abstract mathematical content. So that ICTIP provides meaning-centered learning opportunities and a critical focus on mathematics. We can give examples and non-examples with the concept easily using ICT tools”. This informed that the technology based teaching helps on focused learning. Using ICT tools, students can search learning resources themselves and validate their learning. Likewise, the view of teacher T₅ is; “ICT helps to develop mathematical reasoning if we use it properly and we give more time to ICT integration. We can make students clear on every concept of mathematical problems using mathematical software like GeoGebra, SPSS and Mathematica.” The mathematics software like; GeoGebra, SPSS and Mathematica helps for conceptual understanding that develop mathematical reasoning. The view of another participant T₁₃ is; “ICT helps to solve mathematics problems very easily. We cannot explain all the contents of mathematics through ICT but if we can use it properly many abstract concepts can be taught effectively”. The remarks expressed by participants revealed that it is easy to visualize abstract concept of mathematics using different mathematical software like; GeoGebra, Mathematica, MATLAB, SPSS, Excel. Using that software, lengthy mathematical problems can be solved easily within short time period. In this regard, one of my participant teacher T₁ expressed his view as;

ICTIP helps for conceptual understanding for example; the software GeoGebra and Mathematica help to present the concepts of Limit, derivative, functions, construction, etc. clearly on students. The students develop understanding, concept formation and creation. ICT helps to develop problem-

solving skills. ICT helps to solve large and difficult problems easily (eg. 100 times derivative in a single click).

This view of teacher revealed that ICT integrated pedagogy helps to develop clear concept, problem solving skills and creation on students. Describing the role of ICT for visualizing abstract concept another participant T₄ say,

Some of the mathematical contents can be taught without using ICT tools but we have difficulties to make the concept clear through pictorial representation and visualization without using technology. In my class when I teach phase diagrams, I feel difficulty to give clear concepts by sketching figure on whiteboard but when I use software to sketch diagram and use YouTube videos to teach such concepts with animation then students clearly understand the concepts and were satisfied.

This experience of teacher concludes that some of the abstract mathematical concepts in higher level are very difficult to visualize by drawing picture using conventional method but it is very easy to visualize and conceptualize using technology. This concludes that the technology integrated pedagogy in mathematics classes is helpful for visualizing abstract concepts.

Blended Learning as Benefit of ICTIP

Though ICT integrated pedagogy is a basic requirement of the 21st century teaching learning activities, most of university teachers are confined to use technology based low-level tasks like word processing or presentation of information through power point rather than integrating technology into their subject areas. Teachers could develop various strategies of integrating ICT into their instructional practices at mathematics classes. In a study, Zainal (2012) found that the TPACK model provided a better understanding of how the teacher's different types of knowledge; technology,

pedagogy and content interacted and influenced the integration of ICT in teaching mathematics. However, when the participants were asked about their experiences in integrating ICT tools, most commonly they expressed that their instructional practices were confined to PowerPoint presentation, discussion on messenger group, downloading materials of related contents from Google and YouTube. Further, they use mathematical software or technological models for their teaching purposes. Some of the participant teachers use MOODLE platform using as common discussion forum in their classes. The quotations based on teacher's interview that the dual mode of teaching used by teachers in their classes using ICTIP by teacher T₅ is,

In my ICT based classes, first of all, I give the basic concept of contents withbullets and then solve the problems through ICT media, and at last, I solved the problems on board if necessary. It is easy to teach and provide necessary materials for students through different technology based media.

The view of the teacher reveal that, using different ICT tools and learning platforms teachers provide necessary materials to their students. Teachers use blended mode of instruction in their pedagogical practices which is not possible without using ICT tools. Supporting the view of this participant another participant teacher T₁₈ say,

I used dual-mode teaching i.e. the basic concepts of the subject matter were discussed by presenting them in PowerPoint and the necessary problems were solved on a whiteboard or writing pad. Some contents of numerical analysis, algebra, and differential geometry were taught using software because the visual representation was needed to clarify the concepts.

The above narrative of teachers' strategies about the practices of ICT integrated pedagogy informed that teachers use dual-method teaching i.e. the basic concepts of the subject matter were discussed by presenting them in PowerPoint and

the necessary problems were solved on a whiteboard or writing pad. The view of T₁₇ is similar with the previous views as,

Basically, I use PowerPoint presentations on the theoretical subject of mathematics, and to teach content courses like; Algebra, Analysis, and Geometry, I use a writing tablet and whiteboard simultaneously in my online class. PDF files of teacher's notes were also used in teaching during the period of pandemics.

From the view of teacher, I came to the conclusion that the contentment courses of mathematics were quite comfortable to teach using dual mode of teaching. Only the power point presentation is not sufficient to give necessary steps to solve numerical problems, in such case teacher use white board. In the similar vein, another participant teacher T₇ say,

Some of the mathematical contents and symbols were difficult to type and present on PowerPoint, so, the PDF file of my teacher's note was also used on teaching. After using a writing tablet on teaching it was easy to solve mathematical problems and prove the theorem stepwise.

The view of teacher informed that writing tablet is more convenient for mathematics teachers to write mathematical symbols used on the subject like; Algebra, Analysis, Topology, Differential Geometry and Statistics.

Engaged and Interactive Learning through ICTIP

The ICT integrated pedagogy has made students more engaged and interactive in Mathematics learning. It is found that learning mathematics is mostly influenced by the motivation of learner and engaged activities on the subject matter. In this context, participant teacher T₆ opined;

I focus on conceptual clarity first and then give problems for solving to the students. I advise and convince students not to take math as a burden because the formulas of Mathematics are not so hard. I focused on conceptual clarity and give the process of developing formulas with their terminologies. I give an alternative proof of the formulas. I suggest to them the important site to find a model class so that the students will be able to search the materials properly.

From the experience of teacher what I conclude that to make mathematics class more focused and interactive, teacher must pre informed their students about coming lesson and reading materials. Furthermore, there is excellent agreement between previous research findings and researchers view. In the similar vein, another participant teacher T₁₄ opined;

I use SPSS, Excell, and GeoGebra in my classes to teach mathematics. To make my class more engaged and interactive, I send the link of class videos and reading materials to the students on previous class and said them to learn it before entering in the class. The use of such software and pre informed materials made the classes more focused and content oriented.

This view also informed that using ICTIP in mathematics classes, teacher can easily engage their students on related contents. Agreed with the view of his friends another teacher T₄ expressed; “I feel very comfortable to teach mathematics using PowerPoint because I taught mostly theory courses. Some of my students help me to share the whiteboard on the previous days of using ICT tools in my classes”. This view of teacher informed that there is good collaboration between students and teachers in their classroom. Teachers sometime share fruitful videos and classroom presentation as a model in their classes. Students can use ICT to develop and share multimedia materials that illustrate mathematical topics, including presentations or

films. Peer teaching fosters a social and collaborative learning environment by allowing peers to learn from numerous perspectives while also reinforcing their own understanding. Similar finding has been justified in a work by Camera, that integration of technology is a motivational tool to encourage and engage students in learning Mathematics (Camara, 2013). Overall, the use of ICTIP is contributory towards making mathematics classroom engaged, interactive and meaningful.

Flipped Pedagogy through ICTIP

The use of ICTIP is also found contributory to apply flipped methods in teaching. As a form of blended learning, flipped pedagogy provides necessary materials for students on the previous days of the allocated class, students watch online lectures or required videos, collaborate in online discussions, or carry out research at home and engage in the concepts in the classroom with the guidance of a mentor. It changes the traditional learning setting by providing instructional materials online beyond the classroom premises. In a conventional classroom teachers teach the allocated class on a set period for their students but flipped mastery classrooms follow a mastery learning approach where students fully understand their unit topic before progressing to the next one. The flipped classroom on mathematics contents have positive impact on students' achievement (Ramakrishnan & Johnsi, 2016). Supporting this view one of my participant teacher T₃ say,

I uploaded materials for the next class on messenger group each day and discussed them on the beginning of the class. Beside this, the prerequisite knowledge about the content was shared and discussed at the beginning of the class and the conclusion was drawn at the end of classes. Then we discussed on subject matter by presenting it in PowerPoint. At last, the necessary problems were solved on a whiteboard or writing pad.

From the above narratives of teachers I conclude that Flipped pedagogy is possible using ICT tools and online learning platforms. It increases the harmony in the classroom and makes the students more engaged in the classroom through discussion. If students were pre-informed on their subject matter, they also prepared for next classes and motivated through the class discussion. The same view is given by another participant teacher T₁₂

I give group work, pair work, and individual presentations to my students that help to share their ideas each other. I focused on learning by doing approach through student-centred activities in my class. The effort of each student has been utilized to complete the course on time.

This is the way to use flipped pedagogy in classes, in which the students were actively involved in their learning and they put effort on class. The similar view was expressed by other participants (T₃) as;

... I use flip pedagogy in teaching (I put the materials of the next class on previous days and said the students to study this properly and make an idea to be ready for the next class presentation). At the beginning of the class, students must reflect on their ideas in the subject matter. The students have good access to technology so that all the activities were smoothly run during the pandemic.

This suggests that the use flip pedagogy in mathematics classes provide students a chance to reflect on their ideas at the beginning of the class. The teachers can have opportunities to provide group work, pair work, and individual presentations to the students that help the teacher to complete the course on time. In this regard, the professor of mathematics education T₁₅ with more than 20 years of teaching experience opined that;

If we use ICT properly in online classes, the students do not feel bored when we take classes for a long period. I easily spent up to 4/5 hours in my higher mathematics classes. If we made interactions with our students in classes, then we would not need more effort in teaching. I review the main concepts of the previous class and reflected on the assignment of students each day before starting the class. After discussion, I made seen setting and give new concepts on every content that made the learning permanent.

The remarks expressed by the teacher conclude that the interaction with students on the subject matter made the class very interesting and it facilitated learning process which increases the creativity of students. The ICT tools help to make the class enjoyable and the burden of teacher decreases if they use ICTIP properly to teach abstract mathematical contents. Teachers use mathematical software like; SPSS, Excell, and GeoGebra in their classes to teach mathematics effectively. Beside this, another participant teacher(T₅) opined that; “Even though the physical activity and the psychology of the students cannot be observed in an online class, the friday class is for student interaction and the video of the students should be compulsorily opened at that time”. This view of teacher reveals that they use the classroom videos of different mathematics experts in their class. This helps to validate the knowledge of students as well as cross-check the contents delivered by them.

The description in the paragraphs below depicts the picture of a day’s classroom activities of the teacher and the students in the class. It exemplifies how the teacher and the students used ICT tools in their teaching and learning process.

The lesson was research in mathematics education, from the course new trends in mathematics education (class observation M Ed third semester). The teacher was teaching students what is the recent trends of research mathematics and what practices

in the field of research related to mathematics education going on present day. In the warming-up phase, the teacher involved the students for a while in the discussion about the importance of research in education and some research titles on the field of mathematics education. The discussion was based on the task given by teacher in discussion forum of MOODLE. The students took part actively in the discussion and shared their ideas, some information they had about research and some research titles of their seniors conducted at their institution. After that at his presentation phase, the teacher displayed a short video clip through the projector, which he had downloaded previously. In the visual, a researcher was talking about recent trends in mathematics education. Next, the teacher displayed power point slide showing some research areas of the 21st century. Some of the students noted down the research practices and research title.

In the practice phase, the teacher asked the students to think about some research areas and research problems. He guided them round the class while students were in the practice. After they completed, he asked one of the students to read aloud his research area; and asked all others to listen to that. The teacher gave his comments and some viable research areas of mathematics education and informed students why it is a research problem. All the students listened to the teacher's feedback attentively. Then the teacher asked the interested students to say their answer and give his comments. Finally, as the homework, the teacher divided the students into four groups, and asked all of them to send one of their research problems to the group members; and send their advice/suggestions to the problems sent by the friends.

In this class observation, both the teacher and the students utilized the ICT tools in the teaching-learning process. The teacher used them for materials production and presentation, and the students used them for conceptualizing the subject matter

and sharing the information with their friends. ICT tools were used in searching for resources as well as verifying knowledge. They were also used for learning engagement as part of their homework assignment. ICT offers different tools for simulating problems of mathematics and modelling real-world settings. Students can explore and examine these simulations together in a social constructivist setting, sharing their findings and conclusions. This innovative method makes learning more meaningful and interesting by assisting students in connecting mathematical ideas to real-world situations.

ICT-friendly Curriculum: Need of 21st Century Students

The mathematics teachers agreed that for the effective implementations of ICTIP in higher mathematics classes, ICT friendly curriculum is necessary. As the respond teachers suggest the curriculum design and improvement of TU should be judged at two levels- University and classroom level. At the university level, the curriculum was prepared based on the knowledge, experiences and desires of the person involved in the curriculum development unit. All the members who are involved in curriculum development have high ambitions regarding the standard of mathematics at national and international university levels. For this, the teachers and students of the 21st-century world demand more advanced programs. In the context of TU Nepal, there is a mismatch between the demands of stakeholders and the structure of the curriculum of mathematics. In this concern, the participant teacher T₇ expressed his experiences as;

We must reduce the lengthy course to make the course ICT friendly and make it applied. Some practical activities should be added to each course and should be evaluated practically. The mathematics course should be related with day to day life activities of students.

The remarks expressed by the teacher also show that the students and teachers need a more practical and ICT-friendly curriculum but the reality is not as they demand. Supporting this view another teacher T₉ opined;

The curriculum should enforce the teachers to implement indicated instructions compulsorily. The application-oriented syllabus should be developed by the Faculty of Education. At least one course on each level should be practical based and students should be compulsorily involved in practical classes for their final evaluation. If we revised the course as the need of 21st century, the teaching modality of mathematics should drastically be changed and our manpower can easily be sellable in the market.

This study further found that in order to produce the qualified manpower from the university, mathematics curriculum is required to revise in the pace of technological advancement and there is a need to make them realistic and practical. The teachers suggested that ICT should be integrated in the evaluation process as well. In this concern, another participant T₄ says; “Our students are not convinced about the application of some mathematical contents like; Algebra, Analysis, and Calculus. We should develop the contents of higher mathematics in applied form and a practical portion should be added to each unit of the content.” The inflexibility of curriculum and textbooks has created some challenges in integrating ICT into the mathematics contents (Yildiz, 2007). The view of the participant also mentioned a curriculum that did not require ICT integration because the courses were still very traditional.

The curriculum need to be revised so that ICT can be integrated properly into various contents of mathematics. For example, the respondents (e.g.T₁₀) agreed that the revised curriculum must preserve the critical thinking of the students focusing on

collaboration. The teacher (T₁₀) opined; "... especially, collaboration, cooperation, and critical thinking should be preserved using ICTIP. The result shows that the achievement of students increases when using ICT in our instruction". Participant T₃ gave his view about the shortcomings of the present bachelors and master's mathematics curriculum;

If the curriculum should be activities based and developed as praxis driven as suggested by SUVOT, and then it would be ICT friendly. We should integrate ICT into the curriculum such that it should be used as a tool for learning but not as a subject. The objective, contents, and method should be focused on ICT as fundamental tools in the teaching-learning process.

The view of teachers informed that ICT should as tool for learning rather than a subject. As suggested by SUVOT, the curriculum of mathematics needs to be developed as activities based and praxis-driven. Likewise, another teacher T₁₇ say; "Our mathematics courses are less ICT-friendly. It is not ICT oriented course and the practical contents should be added to each curriculum and relate to ICT-based instruction." This view of teachers focused on the need of ICT-oriented content as well as ICT-based instruction. Supporting this view, another participant T₁₂ opined; "The curriculum should be developed as a guideline for stakeholders. It should be behavioural, vocational and activity-based. Our evaluation process should be revised and integrate ICT with evaluation tools". The remarks of the participant teacher on the in-depth interview informed that we need an activity-based curriculum with ICT friendly evaluation process.

The curriculum is viewed as those specific contents and skills that students are expected to comprehend and apply. This view is reflected in the proposed curriculum standard and the way the mathematics community responded to the study. Talking

about the need for ICT friendly curriculum to apply ICTIP properly one of my participant teachers T₁₆ opined;

We should develop the contents of higher mathematics in applied form. For visualize abstract concepts of mathematics and make the contents more creative, our course would be ICT friendly. ICT-friendly course demands project work, problem-solving skill, creativity, and constructive activities but we have very few courses at master's level in this light. Most of us use ICT to teach content just for understanding but not as means of learning. Not only the course, the evaluation process should be revised and integrate ICT as evaluation tools.

The above narrative of teachers reveals that the ICT-friendly curriculum demands project work, problem-solving skills, creativity, and constructive activities. For this, TU should revise the course of mathematics to at higher level and make it ICT-friendly. Not only the change in the curriculum but also, need ICT friendly environment and evaluation process on each educational institution.

ICTIP as a Means of Instruction in the Pandemic

The COVID-19 pandemic brought many challenges in all aspects of human life all over the world. The field of education and educational institutions remains no exception from this event. The pandemic has caused the closure of educational institutions globally, with more than 1.57 billion learners (90% of the total enrolled students) from more than 190 countries being unable to attend their regular classes (UNESCO, 2020). Like most parts of the world, Nepal imposed a nationwide lockdown and closed all educational institutions across the country on 24 March 2020 as a measure to limit the spread of the COVID-19 virus. While TU did not conduct any formal teaching in the period of the lockdown, it issued two separate guidelines;

the online class guideline' and the electronic communication management guideline' with the objective of running their classes on MS Team (TU, 2020). In this period, ICT tools were used as a means of instruction. In this concern, one of my participant teachers T₁ in his interview says; "It is a golden opportunity according to the environment and movement of COVID-19 to use ICTIP and it leads the teachers and students to face problems and solve these problems meaningfully through different mediums". The view of teachers informed that the pandemic period brings not only the problem but also the opportunity to use alternative modes of instruction to teach mathematics. This view of participants was found similar as the TAM model (Davis, 1989) suggests. Supporting the view of the first participant, another participant T₅ put his view as;

During this pandemic, TU developed MS Teams to conduct online classes, but before this, we have used zoom or messenger groups to conduct classes. The main way of the teaching-learning process during this pandemic was possible using ICT as a medium of instruction. The effect of the COVID-19 pandemic also motivates us to use alternative teaching modality and ICT-integrated pedagogy in mathematics teaching.

This narrative of teachers concludes that teachers were self-motivated and self-directed to use ICT as a medium of instruction in their teaching. Teachers themselves develop messenger groups to communicate with students and create personal Zoom IDs to launch online classes. Using ICT-based pedagogy in teaching before the pandemic may not be mandatory, but the pandemic brought an obligatory situation in which non-users (teachers) of ICT tools must now learn to use it in the classroom. Teachers were using ICT tools before the pandemic significantly less than during the pandemic (Niroula, 2021). Teachers can create interactive problem-

solving exercises that promote group engagement by utilizing ICT platforms. The use of ICT tools encourages students in idea sharing, problem-solving techniques, and knowledge construction. The teacher T₈ also agreed with the view of other participants;

We have no alternative to use ICT due to pandemics, so, our teaching modality changes and we use a blended mode of instruction during and after a pandemic. I feel that all students also benefited from online classes because the students were not interested in joining their physical classes after the pandemic.

The above view of teachers informed that teachers use dual modes of teaching (i.e. physical and online) after COVID-19. The view of students also shows that they are satisfied with the class conducted by teachers in a pandemic. While the adoption of online delivery to reach out to students in the times of the COVID-19 crisis has been prevalent in every corner of the world, this is found more sustained and effective at the higher education level (Veletsianos & Seaman, 2020 as cited in Khanal, 2020). In the case of Nepal, the university system has already acquired some form of online, or at least a hybrid, pedagogical system, and a significant number of the faculties are trained to use technology-based pedagogy in teaching.

Institutional Support: Basic Requirements for ICTIP

The use of ICTIP in mathematics classroom requires institutional support such as ICT-supported classroom infrastructure, equipment and internet support, software and expert services. This study suggests that many teachers lack of knowledge and skills to use ICT effectively as a tool in facilitating teaching learning process. The main problem observed in this study is the unavailability of adequate expertise at the university level. There is a lack of basic infrastructure in some institutions to launch

ICTIP. About the basic requirement for implementing ICTIP in higher mathematics classes, the participant teacher T₆ says; “The management of technical problems, management of effective equipment and ICT training for stakeholder is essential for the better implementation of ICTIP.” This view of teachers informed that there are some technical problems in each institution to use ICT integrated pedagogy effectively. A similar view is expressed by another participant teacher T₁₁;

There should be full access of the internet for students and teachers both because all the students have no such access. The ICT devices should be affordable for students. If we do not include ICT on evaluation then the real condition of the students cannot be found in mathematics.

Notably, the lack of high-speed and reliable internet and access of computer and other ICT equipment is a fundamental problem in mathematics classroom in Nepal. When access is ensured, the teacher needs to put more effort to help students use ICT facilities for mathematics learning. In this regard another participant teacher T₁₄ experienced as; “For providing ICT knowledge to students and applying ICTIP, a teacher should be more active. The provision of physical infrastructure is most for effective implementation of technology-based pedagogy to teach mathematics”. The above narrative of teachers informed that we need basic infrastructure like; physical facilities, ICT devices, internet facilities and trained manpower for the implementation of ICT-based pedagogy in constituent campuses of TU. On top of this, teacher T₇ expressed his view as; “Our education system should be based on ICTs. ICTIP will be more useful in upcoming days if we develop basic infrastructure on each institution.” Besides the infrastructure of educational institutions, there is a necessity of ICT training for teachers. In this concern another participant teacher T₁₀ said; “For effective implementations of ICTIP, we managed recourses equally for all

students. The teachers must be trained and competent to use ICT tools and software.” As the narratives of teachers TU have launched teacher training programmes for the use of ICT, but most of the training activities are over-emphasizing computer literacy while not enabling teachers to integrate technology with pedagogy and facilitate ICT-assisted interactive teaching-learning at the classroom level.

Digital tools: An Alternative Medium of Instruction

The use of ICT in teaching learning process is established as a catalyst for change in this domain. ICTs by their very nature are used as important tools to encourage and support independent learning for students. The students are using ICT tools for learning purposes and more students use mobile and computer as information sources and digital tools. The experiences of teachers reveal that the influence of technology on supporting how students learn will continue to increase achievement in mathematics. Besides the formal media provided by the university, teachers have used different alternative sources during and after the pandemic in their teaching-learning process. The experiences of teacher T₃ expressed on the interview related to the use ICT tools as an alternative medium of instruction is as;

I develop a messenger group on each class. The students have put their queries on that group and I addressed them immediately or in the next class. Some of them help to solve the problems that their friends raise in such group.

The above view of teacher informed that teachers develop different messenger groups, Viber groups or WhatsApp groups for the students of each class for communication and sharing the documents. In this regards, another teacher T₁ say

There is a different WhatsApp group for each class to connect with students and share the documents. The needy students join on WhatsApp group and put

their queries on the group. I solve the problems and share them with the group or discuss it in the next classes.

This is an example how mathematics teacher support their students in learning using different media and role of teacher as a facilitator. The next benefit of using ICT is, needy students can easily communicate with their teachers on their comfortable time and media. This discussion shows that the digital tools were used as alternative medium of instruction and they are used as a means of pedagogical transformation.

Teachers and students during and after COVID 19, use ICT as an alternative way of instruction, whenever they present in their face to face classes. In supporting this view one of teachers T₁₃ opines; “I put necessary information, notice, and some reading materials in the messenger group of students. They have the opportunity to download such materials from group messenger and upload their assignments through google classroom, personal mail or Viber”. This experience of teacher informed that teacher always facilitate students learning and encourage them for interaction and discussion in their classes. For the convinence of students, they use their personal communication tools as well. About the online platform they used, one of participants T₁₇ opines, “The commonly used discussion and communication forum of our students is zoom. They mostly discuss old questions, especially in the period of examination. These days, students are able to submit their assignments on MS teams or Moodle platform”. The main medium of instruction in the pandemic to join online classes was MS teams. Beside this teachers use Zoom classroom, Messenger Group and personal mail to communicate with students.

Teachers can create virtual field trips to investigate mathematical applications in many contexts with the help of ICT. To share their knowledge and experiences, teachers can also invite other speakers to talk, such as mathematicians or experts from

similar subjects. Students' viewpoints are widened and chances for knowledge construction through social involvement are presented by these interactions. In this regard, another participant teacher T₇ said; “Besides MS teams we use zoom classroom, messenger, and personal mail to communicate with students. At the beginning of the lockdown period, we used zoom to conduct the class in online mode.” This narrative of the teacher informed that during the pandemic period, the classes were smoothly run due to ICT infrastructure even though some of them faced obstacles during previous days of the pandemic.

ICTIP as a Change Agent

The primary difficulty to integrate ICT into higher mathematics classes is to bring positive change in the perceptions of stakeholders which is also an additional burden of teachers. It is crucial for ICT integration to become an organic and innate response to teaching and learning moment in the classroom. The focus needs to always be on pedagogy rather than technology. It is essential that the teachers in the developing country must understand how effectively can he organize learning tasks and structure the classroom to facilitate learning through the integration of ICT. As using marker and whiteboard in the classroom is not sufficient for effective learning, ICT resources should serve in the classroom for effective mathematics learning environment.

There are various learning theories and corresponding instructional strategies that can help in learning mathematics. Some strategies that mathematics teachers and teacher educators can use to teach mathematical content through online, face-to-face or in hybrid mode of teaching. The COVID pandemic has made every teacher aware of the need for alternative modes of delivery particularly during any kind of unforeseen crisis. In addition, this pandemic has also provided the teachers with

opportunity to learn and use ICT for virtual teaching. On top of this, ICTIP was used as a change agent in our traditional teaching method. About the role of ICT-based class the teacher participant T₉ says;

The students actively participate in technology-based classes. When we use the conventional method, teachers are active and students become passive learners and they do not have chances to actively participate, in knowledge construction and discussion. When we use ICT in teaching and visualize the concepts through ICT, the creativity of students and participating habits in discussion and questioning with teachers increases.

The above narrative informed that the modality of teaching as well as classroom discourse has drastically changed after the implementation of ICTIP. In this concern there are nine quotations, six codes, four basic themes and one global theme that show ICT as a change agent one of the participant teachers T₁ say; “There is an improvement in the field of education through ICTIP. ICT tools were used as a change agent in mathematics learning.” The view of teachers reveals that the use of ICT in the teaching learning process became a change agent due to its multiple benefits. In this concern another teacher T₄ say; “After the innovation of ICT, our teaching-learning process becomes paperless and device-less. The documentation process of a large file is very easy due to ICT on the personal web page, mail, and google drive safely.” The remarks expressed by the participant teachers informed that the use of ICT in the field of education has itself student-centred learning settings and often this creates some misconception on the role of teachers and students. But with the world moving towards digital media and information, the role of ICT in education is becoming very important and this importance will continue to grow and develop in the 21st century learning skill. Supporting the view of other teachers other participant

teachers T₈ shared his experiences as; “I am fully convinced and satisfied with ICT tools and believe that it helps to visualize the abstract concept of mathematics. The students get chances to manipulate and visualize the mathematical problems through ICT.”

This experience of the teacher concludes that the visualization of abstract concepts of mathematics using ICT tools helps to develop new concepts and clear understanding of students gradually. A similar view was presented by participant teacher T₁₃; “ICT has a positive role in improving students’ achievement. So, we can take ICTIP as a change agent in the process of teaching-learning advanced concepts of mathematics”. From this view of the teacher I was informed that there is a positive role of ICT to improve students’ achievement. In this concern another participant teacher T₁₂ opined;

ICTIP changes the modality of teaching-learning drastically so, it is taken as a change agent in the field of education during and after the COVID 19 pandemic. Using different ICT tools in learning mathematics, it transforms the work performance of teachers and students.

The narratives expressed by my participant informed me that the use of ICT tools and ICT-integrated pedagogy in mathematics becomes a change agent in our classroom. This forecasts the user’s willingness or attitudes towards the use of technology (Davis, 1989). The view of teacher participant T₂ is also similar to this view;

There is an interaction between students and teachers in ICT integrated classes and students actively participate in the classes. After using ICTIP in mathematics classes students change their mindset and sharpen themselves.

We change the teaching paradigm through student-dominant activity in the class.

The remarks expressed by the teacher informed that there is gradual development in technology-based teaching that helps to increase students' achievement in mathematics. The view of another teacher T_6 supports this view as; "ICT-based teaching has a positive role in improving students' achievement. So, we can take ICTIP as a change agent in the process of teaching advanced concepts of mathematics." This view of the teacher informs that the achievement of students improves after the implementation of ICTIP. Students and teachers took ICT as a change agent in pedagogical process.

ICT for Conceptual Understanding

The integration of ICT into the teaching and learning process is a new idea to place pedagogy over technology. For this, teachers need to realize how to organize the classroom to structure the learning tasks so that ICT resources become automatic and natural responses to the requirements. If the teachers were competent on technology, the technology-based classroom moves in the same way as teachers use markers and whiteboards in the classroom. The students develop conceptual understanding when they have the opportunity to use ICT tools as manipulative materials. The view of teacher T_{11} expressed in an in-depth interview supportive of ICT for conceptual understanding is; "The conceptual understanding of students increases through the use of ICTIP rather than using the conventional method of teaching. Our students do not get an opportunity to use software but they clearly understand the mathematical concepts from our visualization." The view of teachers informed that ICT tools help to develop a conceptual understanding on mathematics. Mathematical software made learning quick and easy. The view of teacher T_4 is similar to the above view;

ICT is useful for higher-level mathematics classes. ICT helps in creative discovery and it helps to learn abstract contents independently. Teaching mathematics is not comfortable for virtual classes without using ICT. Basically, we use the book only as resource material to study but after using ICT tools like; computers, and mobile we can search different reading materials besides the prescribed textbook.

This view of the teacher informed that ICT tools help to collect reading materials and validate the knowledge easily. Mathematical software like; GeoGebra, Mathematica, SPSS, and Excel helps to generalize the abstract concepts of mathematics in real life. In a similar vein another participant T₃ says;

In my class, I encourage students on discussions that make students independent and self-learners. For example, to teach the contents of cultural diversity in mathematics education, first of all, I ask students to raise the related issues, find the related research title, and appropriate objectives and link each content with research using different links on Google.

This narrative of the teacher informed that all the students are motivated and curious when they use ICT as a means of instruction in their mathematics classes. After the use of ICTIP students can visualize and understand the concepts of mathematics themselves. In a similar vein, another participant T₄ says; “The opportunity for taking expert classes from the remote area of Nepal and exploring own knowledge worldwide is the main opportunity of ICTIP. ICT helps to develop critical thinking and creativity on students and teachers.” This view of the teacher informed me that Students have an opportunity to take expert classes from remote areas of Nepal and exploring own knowledge worldwide due to ICTs in the field of education. Supporting this view, the participant teacher T₄ expressed his experience;

Some of our students are very creative such that they can search the necessary materials using different ICT resources and validate the knowledge they gained. They search for new inventions and articles on YouTube for knowledge construction. The creativity of students was reflected in their project presentation. They search 3D figures and present abstract concepts. The ICTIP helps students to be critical and helps to increase academic achievement than without using technology.

The remarks expressed by my participant were what I found that after using ICT in teaching learning process the achievement of students increased and they got better grade points in their results. Besides this, students are more creative and critical in technology-integrated classes of the teachers. The use of mathematical software helps students to visualize abstract concepts of mathematics.

Institutional Support for ICT Resources

In the context of constituent campuses of TU, there are limited ICT resources. Not all of the teachers can select, organize, and use learning resources available online and even few of them can create electronic learning resources for mathematics themselves (for example, image, audio/video, animation, and simulation using subjected specific technology software) using digital tools. In this concern the participant teacher T₁₆ says; “I face problem to type mathematical symbols in word file, so I use latex. But due to lack of technical knowledge I cannot make animation and simulation using all mathematical software”. The view of teachers also shows the lack of technical knowledge on teachers to use ICTIP properly. A similar experience was shared by other participants T₇ in their interview as; “There is the problem of high bandwidth internet facilities for students as well as teachers. So, there is a disturbance in regular classes. Most of our students have Android mobiles and some

of them have a laptop.” This view of teacher is what I informed that most of the students face problems of the internet and proper devices to integrate ICT in their teaching. Teachers face problems due to the lack of high-bandwidth internet facilities to conduct online classes during a pandemic.

A similar view was expressed by other participants T₂, T₉, T₁₃ and T₁₅ as; “Due to internet problems, only 70-80% of enrolled students join their online classes regularly. They cannot properly open the application on MS Teams and submit the assignment provided by teachers”. This view of teachers informed that there is irregularity of students due to internet problems on online classes. The MS teams need high bandwidth internet but there is no such facility all over the country. Similarly, another teacher T₁ said;

A single mobile was used to conduct the class of parents and their children, so the time for reading does not match properly. Some of our students go to their friend’s homes for internet facilities and some of them contact the publicschool administration for internet facilities in pay.

Some institutions provide good access of the internet and ICT facilities for students and teachers to integrate ICT into their teaching-learning process. This data informed that there is digital divide among students. There is lack of proper device to the students that is also the causes of irregularity of students in mathematics classes. In this regard one of the participants T₃ said;

We have equipped classrooms with free internet facilities in our campus and we can conduct classes from our own office if the physical presence of the students is not possible. I took many national and international classes and conducted many oral examinations from my home during the period of the pandemic. There is good access to ICT in our department and the classes were

smoothly run during the pandemic through MS Teams, Google Meet, messenger group, and Zoom.

The narratives of my participants informed me that there is no good access of mathematical software and authentic learning materials. Some of the institutions provide free internet facilities for students and teachers and free devices for teachers that help teachers to implement ICTIP in their classes. Not only students, there is digital divide among teachers. Supporting this view another participant T₄ says; “Our central department provides Laptops for all teachers and we have an ICT lab, Smartboard, and fixed multimedia projector in each class. So, we use ICT integrated pedagogy before and after the pandemic period.” Some of the participant teachers use ICT tools and mathematics software regularly and the institutions encourage them to use such technology. Even though there is no good access to mathematical software and authentic learning materials on some campuses of TU. Some of the teachers from new generations T₅, T₆ & T₈ use mathematical software and ICT tools for teaching. They share their view;

As a teacher, we do not face problems about the access and use of ICT tools to teach mathematics at a higher level because we already used ICT tools before my profession. Some of the new media and learning platforms were used for the learning by doing approach.

From this view of teachers I was informed that ICT tools and mathematical software were inseparable for mathematics subject. So, every institution needs to support ICT-integrated pedagogy for the betterment of students’ academic achievement. The importance of ICT tools and ICT-integrated pedagogy was felt during the COVID-19 pandemic. Teaching and learning from distance mode has been a good alternative at a time when the whole globe is affected by infectious disease. In

this regard, TU decided to run the classes of Bachelor and Masters Level on online mode and developed infrastructure as well as a learning environment for online mode of teaching.

The resourceful institutions and the institutions funded by INGOS provide free internet facilities for all stakeholders and free devices for teachers. This is supportive for teachers to implement ICTIP in their classes. Due to geographical difficulties, students of remote villages of Nepal miss their online classes during a pandemic. The Wi-Fi network on Nepal is not good and accessible for all. So, students and teachers face many obstacles to conducting online classes. Eventhough, as a data published by Nepal Telecommunications Authority, 2.25 million new users were connected to the Internet in 2017, translating into approximately 250 new internet users every hour (MoCIT, 2019). Some of the sample teachers are competent on technology but a majority of the teachers face problems in integrating ICT into their mathematics teaching due to technical knowledge. Some of the constituent campuses develop ICT labs that facilitate practical activities and learning by-doing approach in their teaching-learning process.

The constituent campuses situated on the urban areas develop good ICT infrastructure for teachers and students. In this concern, one of my participant teachers T₁₄ expressed his view; “Our institution provides good opportunities for technology and free Wi-Fi facility. During the period of the pandemic, the campus administration provides access to online classes for students and teachers so that we can conduct our classes from our own house”. The teacher opined that the institution develops a basic ICT-friendly environment for students and teachers. However some of the institutions do not fulfil the basic need of students and teachers to integrate ICT into mathematics teaching. In this issue the teacher participant T₁₈ say;

There is no remarkable support from institutions for students and teachers. There is discrimination between permanent and temporary teachers in our campus. The Numerical analysis course demands ICT lab but there no provision of ICT lab in our campus. We have resources but due to the political influence, the campus does not develop basic requirements for integrating ICT to teach mathematics. We teachers and students personally afford the ICT tools during a pandemic to learn mathematics.

The above view of teachers shows that there is a lack of plan and policy for the effective implementation of ICTIP at a higher level. The personal effort of students and teachers made it possible to lunch online classes in a pandemic. Some of students and teachers start using ICT tools on during COVID 19 pandemic first time. The opinion of the teacher T₅ also justifies this logic; “Basically, after this pandemic due to COVID-19, most of the teachers and students use ICT in the teaching-learning process. From the beginning of the first lockdown, we start our online class on licensed zooms first time in our institution”. The remarks expressed by a teacher what I found that during COVID 19 there was a remarkable change in policy and practices of teaching and learning. In this period ICT plays a critical role in the maintenance of face-to-face classes by replacing online classes. ICTIP was necessarily used by every teacher in their classes even though there are resource and time constraints to integrate ICT into mathematics classes. Supporting this view, the teacher T₁₇ says:

We need more effort to develop materials for mathematics and it is not possible on the mobile app. The teaching-learning would be effective if we use such materials. The classes in mathematics are effective if we use ICTIP properly but there is a lack of proper time and devices. I need lots of time developing PowerPoint in the first lockdown for mathematics teaching.

This narrative of teachers enforces the necessity of more effort to teach mathematics integrating with ICT. His experience also shows that the proper device is essential for students and teachers to use mathematical software and develop materials for effective mathematics teaching.

Role of ICT in Promoting Equity and Pedagogical Transformation

ICT-integrated pedagogy has a crucial role in maintaining equity in the class and transformation in pedagogical practices. The experiences of teachers indicate that there are remarkable changes in teaching-learning process after the innovation of ICT tools. The role of ICTIP in promoting equity and pedagogical transformation is presented below:

ICTIP for Promoting Equity

ICTIP has been found an important teaching strategy in mathematics classroom in order to provide wider learning opportunities to all students, including low-ability and marginalized students. In particular, the students who feel hesitant to interact in face to face classroom were found interactive in virtual classroom. The low-ability students could consult teachers through online means such personal mail and messengers.

Digital technologies support the inclusion of the groups of diverse students in education in different ways including enhancing the accessibility of educational content, increasing the personalization of learners and providing distance learning opportunities effectively during the COVID-19 pandemic. Likewise, digital technologies promote equity and inclusion in education generally and for the neediest students particularly (Gottschalk & Weise, 2023). On top of this, the response of teachers shows ICT integrated pedagogy helps to promote equity in the classroom so that all students can learn equally and the needy students also benefit from their

teachers. The perceptions of respondents on teachers' interviews and students' FGD are presented in the following paragraphs.

The view of the teachers informed that if teachers use ICT-integrated pedagogy properly, it helps to promote equity in mathematics classes by addressing individual differences of students. In this concern, respondent T₄ says;

Equity means unequal treatment for equality. ICT provides an opportunity for needy students to consult their teachers about their confusion in a comfortable time, and teachers easily address their problems. ICT is an easily accessible medium of instruction for weak students for self-learning and it is a good platform for them to communicate with their teachers when they need help in the subject matter.

In ICT-based class all the students have equal opportunities to learn mathematics and the teacher provides an opportunity for the needy students to consult with him. Using different media like; Moodle, messenger, email, Viber, and zoom classroom students can communicate with their teachers other than the regular class. The week students on mathematics got chances to communicate with their teacher on their comfortable time and places. Explaining the role of ICTIP in promoting equity in the class the participant teachers T₉ expressed his view as; "ICT helps to promote equity pedagogy in mathematics classes. In my experience, the disadvantaged group of students also benefited from ICT-based classes". This statement highlights the potential of ICT in creating an inclusive and equitable learning environment. By using technology, teachers can provide personalized and differentiated instruction that caters to the diverse needs of students. This can help to ensure that all students including disabilities or from disadvantaged backgrounds, have access to equal education and equal opportunity in learning.

ICT provides various tools and resources that support different learning styles and abilities. Additionally, digital platforms and online resources can offer interactive and engaged learning that addresses the needs of diverse learning needs. In this concern, another teacher T_6 expressed his view; “ICT helps to promote equity pedagogy in mathematics classes. There is an opportunity for needy students to contact their teachers personally”. The remarks expressed by the participant teacher found that the use of technology in the teaching learning process is more beneficial for needy students. By incorporating ICT into mathematics classes, teachers can create a more inclusive and equitable learning environment. This aligns to promote equity in education that ensures every student has equal access to high-quality instruction and resources, regardless of their background or abilities.

The description in the paragraphs below depicts the picture of a day’s classroom activities of the teacher and the students in the class. It exemplifies how the use of ICT integrated pedagogy helps to promote equity in their classes.

The online class about 15 years of teaching experience male teacher observed on March 29, 2021, was concerned with the role of ICTIP in promoting equity in mathematics classes. The lesson of the day was Rolle’s Theorem from the course Real Analysis of B. Sc. second year. After warming up the class, the teacher asked their students, the statement of Rolle’s Theorem, the relationship between epsilon and delta, supremum and infimum based on their class at grade XII. Then, he opened Geogebra software in the class that helped to give the basic concept of Rolle’s Theorem with its geometrical interpretation using GeoGebra software. Then, using powerpoint presentation, he explained and discussed the conditions of Rolle’s Theorem and proved the theorem with examples. The students actively participated in watching the power point and question-answer discussion initiated by the teacher.

There was an equal participation of the students and teacher personally cares all the students so that each student somehow understood the concept. At the end of the class, the teacher encourages all the students to raise questions for him and give the answer of students with clear interpretation. Finally, he gives the assignment for students. He divided the students into six groups and informed all students to prepare the answer individually first, then to share the answer to the group members. He informed students that if they have any problem for their assignment, they can ask him personally through any media. In this way the group needed to finalize the answer.

In this observed class, the teacher use ICT tools for materials production and presentation on his teaching. Likewise, the students used ICT for conceptualizing the subject matter; and sharing the information with their friends. There is equal opportunity for all students to participate with discussion and put their problems in the class. Beside this, the needy students can communicate their problems with their teachers and got solution as their comfortable time and media. Teacher tries to facilitate the mathematical concepts for all students equally and he gives personal care for weak students on the class. The activity of the teacher helps to promote equity in the class. But, the teachers' limited use of ICT facilities indicated that perhaps the teachers had a low level of ICT skills and a lack of motivation to use available ICT facilities in their teaching plans and delivery.

Overall, by using technology, teachers can provide personalized and differentiated instruction that caters to the diverse needs of the mathematics students. This can help to ensure that all students specialization in mathematics including disabilities or from disadvantaged backgrounds, have access to equal education and equal opportunity in learning. There is personal caring of teacher for the weak

students who can not solve the given problem. The ICT tools helps students for conceptualize the subject matter and share their progress with their friends. The students who is unable to conceptualize the abstract mathematical concepts can communicate with their teachers beyond class using different medium of communication.

ICTIP for Pedagogical Transformation

ICTIP is found as a strategy of pedagogical transformation in mathematics classroom, particularly from traditional chalk-talk to technology-based classroom. The transformation on pedagogy or transformative pedagogy is a progressive educational approach including democratic constructivist-based teaching technique for the promotion of democratic ideals and social justice that transform students and society. There are eight quotations, five codes, four basic themes and one global theme on the basis of experiences of teacher on ICTIP as a means of pedagogical transformation. In this regards one of the teacher T₇ say; “ICT helps for shifting pedagogy and allows self-learning and motivation. ICT changes the modality of teaching at higher level.” This narrative of teacher reveals that the teaching modality on higher level changes using ICT tools. This is one form of pedagogical transformation. Supporting this view another participant T₃ say; “ICT helps to change the dimension of teaching by encouraging all students on learning. ICT helps to search new materials and makes the students independent.”

The experience of teacher informed that ICT tools made the students independent and self-regulated such that the learning dimension changes from the traditional teacher centric approach. In the similar vein another teacher T₁₂ opined; “ICT tools helps to develop searching habits and learning by doing skills on students. Hence ICTIP helps for the pedagogical transformation”. Likewise, there is a similar

view of another participant T₉, he expressed “We use students centered teaching in mathematics class through ICT tools and software. ICT helps to shift the conventional teaching methods to the recent teaching methods”. The above view of teachers informed that ICTIP helps for pedagogical transformation by developing searching habit and learning by doing skill on students. In the same context, another participant T₅ say; “ICTIP promotes learning by doing skill and make conceptual clarity. The learning habit of students drastically changes, which is a pedagogical transformation.” The view of teacher informed that the ICT based teaching serves as a catalyst for a better and effective learning environment in mathematics classroom. ICT is flexible tools to come across the learning needs of students and develop favorable learning environment managed by the classroom teacher.

Likewise, another teacher T₂ expressed; “In developed countries, ICT is used as the medium of delivering content and concept development. During this pandemic period, there is a pedagogical shift in our teaching-learning process using ICTIP”. Through the use of ICTs, the efficiency and effectiveness of learning can be improved Students arrive in our classrooms with the full range of motivations towards learning during pandemic as well. This is one of the transformations on teaching learning process.

In the similar vein, the respondent teachers T₁ responded that “ICT makes changes in our behavior and teaching process. The teaching-learning process is drastically changed through ICT and it is a milestone for pedagogical transformation.” The remarks expressed by the participant teacher informed that after using ICT in teaching learning process the behavior of the teacher and teaching process changes that is a milestone for pedagogical transformation. The view of the participant T₁₅ about the role of ICTIP is “After using ICT tools in teaching mathematics, the

achievement of students' increases and it promotes learning by doing approach. The collaboration and creativity increase on students after the implementation of ICTIP on higher mathematics classes." The frequent use of ICT tools in learning promotes learning by doing approach on students. Besides this, practices of ICTIP in class increases creativity and collaboration on students. To express the importance of ICTIP and its impact on teaching learning process one of my research participant T₃ express his view as;

In my experience, ICTIP is the foremost medium of instruction for pedagogical transformation. The transformation is taken as pedagogical shifting. Before using ICT, we generally used one-way teaching strategies. Teachers gave their lectures in the class and they feel hesitant when students ask questions in the class and they do not make harmony with their students. But after using ICTIP in the class, the teachers-students interaction increases and reduces the distance between them.

The above view of mathematics teacher taught higher mathematical content shows that after using ICTIP the teaching learning process is slightly changed and it helps the students for self-motivation and develop creativity on learning. The connectivism theory also believes that the technology should connect with the mathematical contents so that the achievement and interest of students in mathematics increases. In this regard, Prensky (2010) reported from his widespread research that many students feel monotonous when they are at their learning institution. But, if teachers became adaptive and competent on technology such that they could guide their students properly rather than tutor can bring transformation in the teaching learning process. Further, Prensky (2012) states "...computer games, videos, email, Internet, cell phones, and instant messaging are integral parts of student's lives" (p.

68). This shows that students are more connected to the globe through technology these days than their previous generations. This type of generation gap existed between the ways that teachers and students think could be filled by technology-based pedagogical practices (Prensky, 2012). Further, he opines that the technology integrated learning strategies promote students to collaborate with their friends to solve their mathematical problems, and work independently being facilitated by teachers. My own experience believe the ICT tools and mathematical software helps students to make their learning autonomous and use their passion and interests in learning abstract concept of mathematics. This is an example of transformation on teaching learning process.

In addition, ICT plays a vital role in enhancing teaching and learning processes and better shape student's achievement if it is integrated into the curriculum appropriately (Razak et al., 2018). Likewise, the impact of ICT integrated pedagogy can be seen in terms of rapid shifts in educational paradigms. Supporting the view of Razak, my participant T₁₁ says,

In my experience, ICTIP is the main medium of instruction for pedagogical transformation. In these days, we feel a burden to take marker and duster to go to my classes. This means that there are drastic changes in the teaching-learning process after implementing ICT-based pedagogy. The skill of teachers and students increases after implementing ICTIP. This leads me to run my classes using a multimedia projector these days.

The view of teachers and my observation shows that the teachers and students became skill-full on technology after COVID 19 and during the period of pandemic that helps to increase the achievement of students on mathematics.

The description in the paragraphs below gives a picture of a day's classroom activities of the teacher and the students in the class. It exemplifies how the practices of ICT integrated pedagogy and ICT tools in class changes the teaching learning dimensions of mathematics classes and helps them for pedagogical transformation.

The online class was observed on May 21, 2021 concerned to find the role of ICTIP as a means of pedagogical transformation. The lesson of the day was Galois group of polynomial from the course Abstract algebra of M. SC. second semester. After warming up the class, the teacher asked their students about basic concept of ring, field, splitting field, polynomial equation based on their B. Sc. content. Then, he shared whiteboard on classroom and gives some example of transitive group, discriminant of cubic polynomial, Galois group of cubic polynomial with suitable example. Then, he display power point and explained the conditions to show how a polynomial will be Galois group of polynomial. The students participated actively in the class on question-answer and discussion initiated by the teacher. The teacher presents a classroom video from YouTube to justify the conditions that every irreducible cubic polynomial's Galois group is either S_3 or A_3 . At the end of the class, the teacher encourages all the students to search the classroom videos by giving different sites that help them to search for necessary documents on the topic. Finally, he gives the assignment for students. He informed all the students to prepare the answer individually first, then to share the answer to the group members, finalize the answer and submit it on Moodle or messenger group or personal email. At last, he shared a link on the class with date and time of virtual class with foreign professor of algebra.

In this observed class, the teacher and students used different ICT tools in their class for visualizing the abstract concept of mathematics and sharing the information

using modern technology. This is an example to show how the teaching- learning process changed and it brings transformation on our pedagogical process due to ICTIP. Besides this, the needy students can communicate with their teachers on comfortable time and media even though the physical presence on the institution was not possible. The development on technology helps learner for easy access on resources as well as share their ideas globally. The view of the teacher coin with the concept of TAM model that suggests when new ICT tools is presented to students and teachers, their decisions about their practices is influenced either by their perceived usefulness, or perceived ease of use (Davis, 1989).

Opportunities and Challenges to Implement ICTIP

To identify the major opportunities and challenges to implement the ICTIP on higher mathematics classes a question " What opportunity and challenges do you encounter regarding the integration of ICT in solving higher mathematical problems?" was asked to the students during the FGD. A similar question was explored through an interview with teachers. The responses of the FGD and interview were coded in ATLAS.ti using inductive coding.

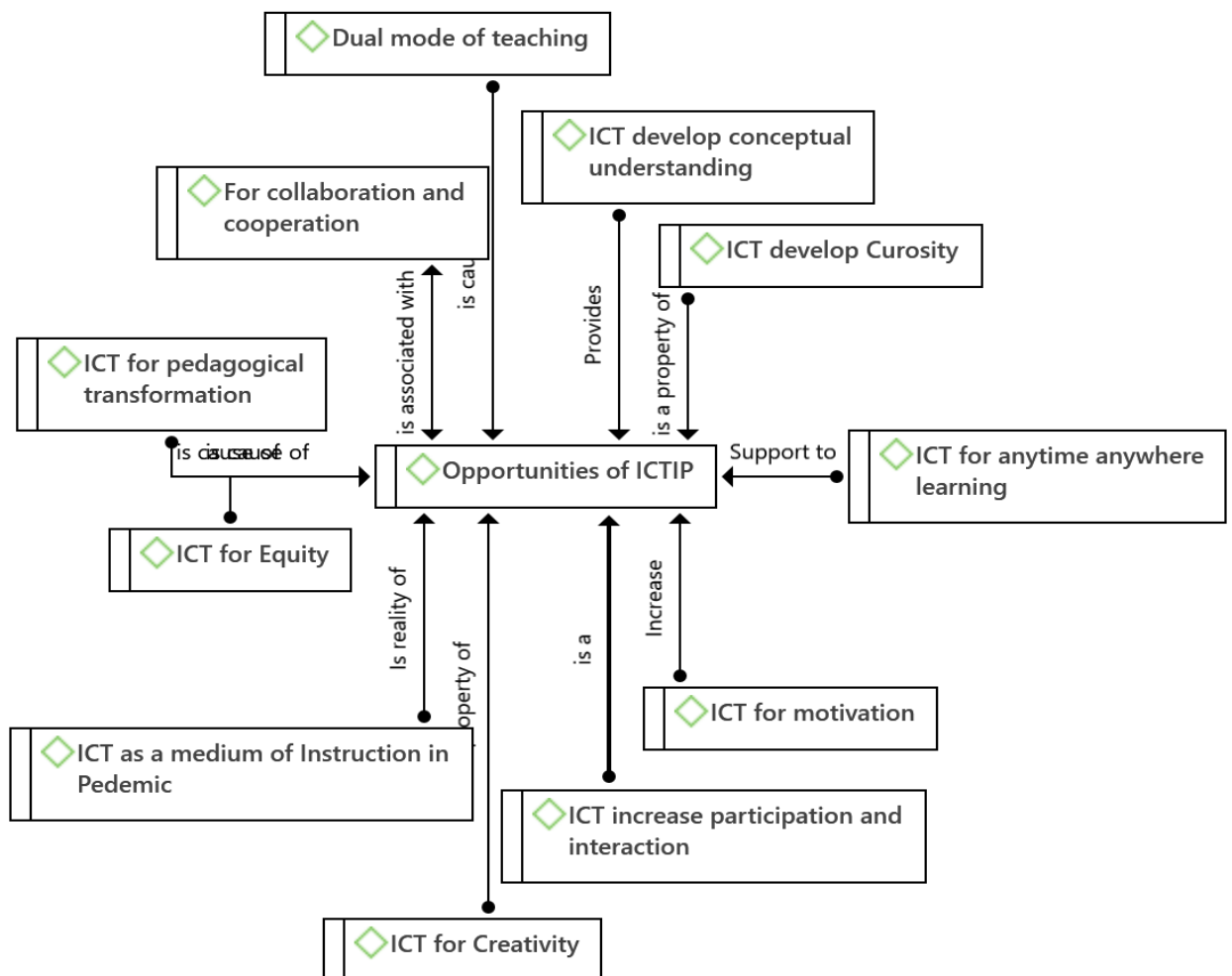
Opportunities

There are many opportunities for students as well as teachers from the effective implementations of ICTIP in higher education mathematics classroom. On the basis of teachers opinion, it conclude that ICTIP develops conceptual understanding on students who were engaged in learning mathematics. The use of mathematical software like; GeoGebra and Mathematica helps students to present the concepts of Limit, derivative, functions, construction, etc. clearly. Beside this, the proper implementations of ICT helps to develop problem-solving skills on students. It helps to solve large and difficult problems easily (E.g. 100 time's derivative in a

single click). The implementations of ICT based pedagogical is more supportive for concept formation, creation, and visualization of abstract contents. The regular use of ICT makes easy access to resources as well as sharing own ideas in the global village of the learners' community. Additionally, it helps to develop awareness of media and online skills and reduces fear in teachers and students that helps to validate their knowledge, and familiarized with methods and media.

In this study, 191 codes as practices of ICTIP were generated and supported by 581 quotations. Some networks of codes created by ATLAS.ti. on the themes opportunities for for learners to apply ICTIP are presented here in below:

Figure 9 Codes Supporting to Opportunity of ICTIP



The practices of ICT in mathematics teaching helps with the application of the theoretical knowledge developed by the students. It assists for students-centered learning, self-motivation, meaningful learning, concept development, and paperless learning by connecting each individual to the source of knowledge. The experience of teacher informed that practices of ICT helps teachers to teach subject matters differently and effectively. It also helps on the mass teaching (same class delivery for all students), knowledge triangulation and authentication. Likewise, ICT integrated pedagogical practices promotes equity on the class and helps for the pedagogical transformation by making students creative, critical and collaborative. In addition to this, ICT helps to increase the self-learning culture on students and made them self-reflective which helps the learning permanent. The proper utilization of ICT tools helps teachers to assess students' understanding properly. Additionally, using different communication platforms students can discuss their peers and work together to improve by collaboratively.

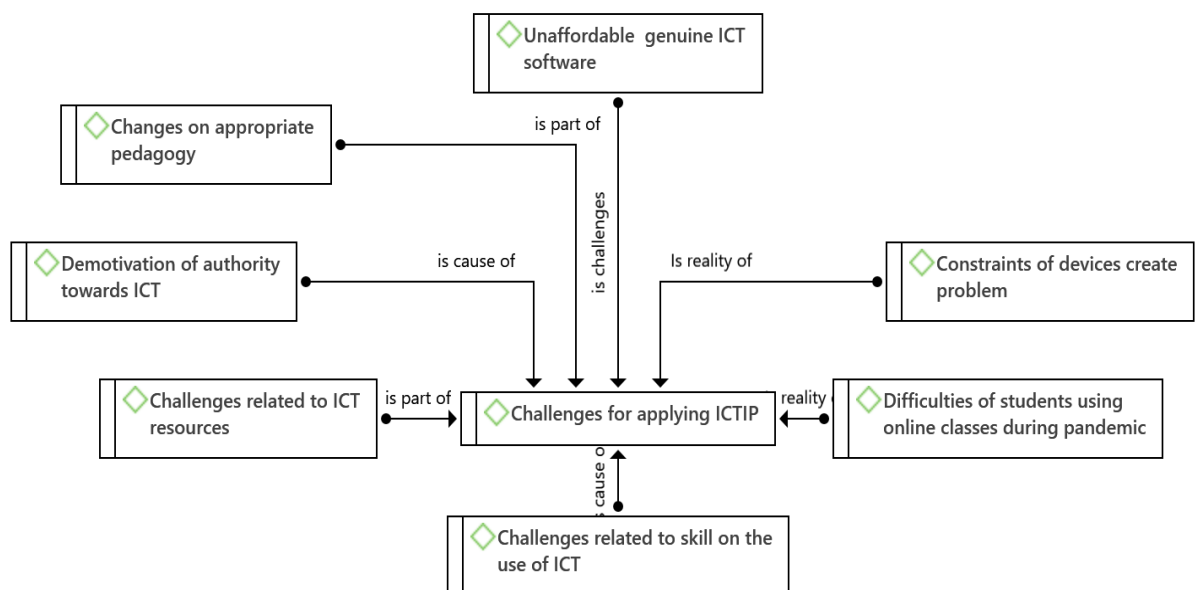
There were other similar answers in the teachers' response. Among 18 teachers, fifteen teachers reported that they give the opportunity for recording their online class to their students. This shows that students got anytime anywhere learning opportunity through Teams and they can listen the recorded class time and again to improve their understanding. The online resources like video lessons and other digital resources helped students to learn when they are in need. Another major function of ICTIP for the effective learning is content permanency and sharing culture.

Challenges

In this study, as mentioned previously, several opportunities were reported by the teachers and students in using ICT. Despite the opportunities, the implementation

of ICT integrated pedagogy on higher mathematics classes, some challenges are perceived. Some research studies conducted by the researchers (such as Van Dijk, 2005; Traxler & Kukulska-Hulme, 2005) concluded that the integration of ICT in teaching-learning process, particularly in a developing country faces many problems and challenges. Lack of adequate infrastructures, problems in the availability of ICT resources and poor technological skills are some of the major problems that the educational institutions need to face. During the implementation of ICTIP the students and teachers were asked to reply on "What are the challenges to implement ICTIP to teach the content of higher mathematics?" There were 16 students participated on FGD and 18 teachers participated on interview. Based on the results of data analysis, it is found that challenges perceived by the teachers and students supporting to challenges of applying ICTIP in mathematics classes supported by Atlas.ti. is presented below:

Figure 10 Codes Supporting to Challenges for Applying ICTIP



Poor Internet Access

Internet access is a perceived challenge to implement ICTIP in higher Mathematics in the context of Nepal at the time when this study was carried out. Most of the students and teachers reported that internet connection is not good. Most of the time they had to rely on slow internet connections. The quotation towards internet accesses based on the interactions with teachers T₃ is; “Slow Internet connections making me frustrate to conduct online class smoothly”. During COVID 19 pandemic most of the constituent campuses of TU run their classes on online mode. The low bandwidth internet connection and instability of electricity creates problems to conduct the online classes smoothly. The similar problems was experienced by T₁₃ as; “Most of our students have no free Wi-Fi at their home. In campus, the internet connection is not good. So, there is problem to apply ICTIP in the classroom”. The lack of resources is another problem for integrating ICT into pedagogical practices. The view of student S₁₂ is similar as above view of teachers. “The mobile data is very expensive. So, I missed many online classes”. The analysis of data conclude that the resource constraints and unstable internet facility is also the casus of irregularity of students during online classes. There is a need of free Wi-Fi facility on campus for ICT integrated pedagogical practices. In this regards, the participant teacher T₉ say; “We have no high bandwidth internet facility, so we face many problems to conduct classes on Teams. We need free Wi-Fi at campus”. The slow internet creates problem to play videos and uploading documents on Teams or Moodle. Some of the online classes were disturb due to poor bandwidth internet facility. But some of the sample campuses were resourceful for integrating ICT in teaching mathematics. Teachers conduct their classes on blended mode from their own department. In this concern one

of the participant students S_6 opined “There is free Wi-Fi facility in our campus, so our teacher conduct their online classes from campus permises”.

The narrative expressed by the participant teachers and students conclude that to conduct online class on Teams high bandwidth internet facility is needed for students as well as teacher. Besides this, due to geographically remote areas, students and teachers struggle to apply ICTs in their teaching learning process. Like many other Asian countries, the mobile services industry in Nepal has recorded remarkable growth in the past four to five years. Mobile penetration increased exponentially to 113% in 2017 from 21% in 2009 (MoCIT, 2019). The present situation of the bachelor and masters classes shows that most of the students used smart phone to conduct their online classes. This makes the teaching learning process more effective and accessible.

About one third of the sample campuses have no free Wi-Fi facility that creates problems to conduct class in blended mode. In this regards, one of participant teacher T_{15} responded that “In the previous days, we face many challenges to implement ICT integrated pedagogy due to poor internet connection and less competency in ICT. So, the digitalization of mathematical content for class preparation is a very challenging job for me.” This narrative of teacher present the self realization of less competencies on ICT and the realities of Nepalies education institutions. Supporting the view of the teacher another teacher T_3 responded that “Due to internet problems during the pandemic time some online classes were disturbed and students seem unhappy. The inconsistency of electricity creates problems in our online classes as well as using different software and ICT tools”. From the above data, it shows that internet connection is one of the major challenge to use ICTIP in mathematics classes. Due to the internet problem, students are suffering

to join online class and get access on resources. Therefore, poor internet connectivity was perceived a challenge to use ICTIP. During COVID 19 pandemic, the physical class was not possible and University decided to run all the classes on online mode through Ms Teams or Zoom. Due to lack of dedicated electricity connection, the regular classes on scheduled time was not possible. Thechers use alternative time schedule to conduct their classes.

Device Constraints

Device management is a perceived challenge to utilize ICTIP in higher Mathematics classes. This is one major challenge reported by students that they are lacking ICT devices such as mobile and laptop. The wiew of students S₅ on device constraints is; “I have mobile but no laptop. Without laptop, I am facing problem to use mathematical software for visualizing abstract concept of mathematics”. The digital divide is the major causes for students dis-satisfaction and huddles for applying ICT integrated pedagogical practices effectively in higher education mathematics classes. Without proper digital device, students face many problems to use mathematical software because the mobile phone is not compatible for all mathematical software. There is lack of smart phone for some students from remote areas of Nepal. The opinion of student S₁₃ on online FGD indicate the realities. He say; “I have no mobile, no laptop. I join online class on my parent’s mobile”. There is similar opinion of other student S₉; “I need smart phone to conduct online class because I have no laptop and I have no money to purchase such a device”. This data informed that there is device constraints among students. They can not effort proper device that creates problem for their effective mathematics learning. It is impossible to lunch the mathematical software like; GeoGebra, Mathematica, SPSS, Excell on mobile phone. Likewise, another student S₁₂ opined; “I did not have a chances to learn

mathematics practically using mathematical software on a laptop or desktop due to lack of a device”. Students failed to visualize mathematical concepts due to lack of proper device. The opinion of teacher T₁₅ also supports the lack of proper device for mathematics; “Due to the lack of proper devices, some of our students are unable to join the online class during a pandemic period and they fail to practice on their homes as well”. Teachers also face several problems of digital divide on campus as their appointment and permanency. One of the participant teachers T₆ opined; “In the previous days of using ICT, we face difficulties in conducting online class and there is a problem joining students on ICT devices”.

The opinion of the students and teachers informed that teachers and students faced problems on integrating ICT due to device constraints and ICT knowledge. Despite rapid urbanization in recent years, Nepal is one of the least urbanized South Asian countries. The World Bank estimates that only one-fifth of the Nepali population lives in urban areas, while more than 80% of the population resides in rural areas (MoCIT, 2019). The students from remote areas of Nepal have less access on proper device and social media networks that creates problems to apply ICTIP in classes. Students use alternative device to join their online classes and project work preparation. In this regard, teacher T₁₁ responded that “It is necessary to have a laptop for better learning because it is difficult to download necessary materials from Mobile”. In this situation, the interested students didn’t get a chance to use essential learning resources. Most of the mobile application is not software friendly. So, it creates problem to learn mathematics using mobile phone only. Supporting the above opinions, another teacher T₈ responded

Lack of appropriate devices, mathematical software, trained manpower and demotivation towards ICT are some challenges to using ICTIP in higher

mathematics classes. Even though we use our efforts on ICT based pedagogy but the university authorities were not responsible and serious about it.

The constituent campuses and universities in urban areas lack proper facilities and funding to maintain laboratory materials and curriculum to keep pace with new technologies and the campuses hard-to-reach remote areas face problems to use wireless and satellite technologies to connect institutions' IT infrastructure. In this situation there is challenges to integrate technology in to pedagogical practices.

The similar opinion was the respondent students S₁₃ on FGD "I have a simple mobile, so it is very difficult to use mathematical software from this Mobile". This version of students reported that our students faced problems integrating ICT in their learning because they have neither a smart mobile nor a personal computer.

Therefore, device management is perceived as a challenge in the context of Nepal. In this regard, one of my participants T₆ said;

Internet problems, geographical difficulties, lack of proper devices, lack of training for teachers, lack of mathematical software, improper physical environment, lack of competent administrative manpower, lack of parents' awareness, negligence of authority towards academic enhancement, lack of equipped classes, lack of computer lab, lack of practices for students and lack of motivation for teachers are the challenges to implementing ICTIP in classroom properly.

The above view infers that in order to integrate technology tools and bring improved technological skills for effective instructional practices, teachers challenges need to be minimized in their profession. As a result, this improved practices in the classroom would prepare students to compete in a technology-based workforce.

Teachers and students faces physical as well as academic challenges to integrate

ICTIP in higher education mathematics classroom. There is problem of proper motivation for teachers to integrate ICT in their pedagogical process.

On top of this, the participant student S₁₅ on FGD also shared that there were some problems related to the infrastructural management. No regular electric supply and slow-speed Internet were some of the main problems they encountered. He shared “We mostly face technological problems like slow Internet, expensive data pack, and that we sometimes need to wait for electricity for internet”. Some of them also reported that there was sometimes no proper maintenance of the devices like keyboard, mouse, and USB in the e-library and mathematics lab even though some of the institutes have such facilities. It was also reported that their parents did not have a positive attitude towards the ICT devices because the parents of the students who enrolled on constituent campuses of TU are from average socio economic status. The other challenges include lack of professional training, problem on internet connection to applying ICTIP in mathematics classes for teachers. In this way, the educational institutions of Nepal faces infrastructure as well as policy problems to integrate ICT in their pedagogical process.

Chapter Six

Summary of the Findings and Discussion

This chapter presents and discusses the major findings under the five research questions aligned with the research purpose that aimed at exploring the experiences of teachers and perceptions of students in ICT-integrated pedagogical practices in higher education mathematics classes. In doing so, connections have been made between the thematic findings and the literature. The major findings from the study have been discussed in relation to the literature (Pietkiewicz & Smith, 2014). The interpretations have been presented in connection with the theoretical, thematic and empirical literature. Additionally, this chapter presents the overall reflections on the major findings.

Interpretation and discussion are the most desirable procedures of analyzing data and getting findings in a systematic research area. So, the findings of this study have been discussed based on the theoretical and philosophical perspectives of social constructivism and connectivism along with the TPACK and TAM framework which the research is based on. In an educational research, interpretation represents the activity of making sense of data and findings. According to Yin (2016), interpretation is the craft of giving meaning to the findings. In this concern, Creswell (2014) writes that interpretation and discussion in educational research mainly include the activities such as summarizing findings, giving personal views or reflections, and comparing the findings with past studies. Yin (2016, p. 221) discusses five considerations for good interpretation viz. (i) completeness (having a beginning, middle and end), (ii) fairness (giving interpretive stance), (iii) empirical accuracy (representing the data), (iv) value added (adding new interpretation/reflections), and (v) credibility (having

others' acceptance of the interpretation). So, my interpretation in this study is based on this direction.

The major findings of this research were presented under five headings and sub-headings in terms of students' perceptions and teachers' experiences in the practices of ICT integrated pedagogy in higher education mathematics classes, comparison of the perceptions of students, role of ICTIP for promoting equity and means of pedagogical transformation, opportunity and challenges on the practices of ICTIP in higher education mathematics classes, and the effect of general practices of students and input of ICT on output of ICTIP. The discussion and interpretation has been shaped in relation to literature, triangulating the findings derived from different resources, and incorporating my personal experiences and reflections in the succeeding sub-headings.

Students' Perceptions Towards the Practices of ICTIP

The students' perceptions towards the ICT integrated pedagogical practices refers to the feeling of students concerning the practice of ICT tools and techniques by the teachers in their higher education mathematics classes. Mainly two types of perceptions were identified in this study. The first perception is that ICT integration should be mandatory and interest-based. As expressed by the students teachers and who were familiar with ICT tools provoked it is mandatory and those who had little knowledge about ICT claimed it is to be interest-based. The second perception found from my observation and discussion with participants was that the practices of ICT integration in mathematics classes mainly included brainstorming, self-presenting, collaborative, problem-based learning and project-based learning methods, and these methods promoted students' creativity and created collaborative learning environment. In this regard, Amadi (2012) has shown that ICT integrated pedagogy

promotes the collaborative and collective approach involving students for meaningful learning. From the perceptions of students what I found was the ICT tools can be integrated through the brainstorming, self-presenting, collaboration, problem-based learning and project-based learning methods. Students' engagement and learning can be enhanced through the collaborative and engaged learning strategies. As ICT-integrated learning requires multimethods and wider activities for problem solving, learning in groups helps students explore the problems through collective brainstorming. When students have a clear idea about the problems or issues through brainstorming, they can choose the tools and activities for collaboration among peers. The collaborative activities are always significant and meaningful for problem-based learning. In this way, as students suggest, ICT-based learning in mathematics classroom can be effective if the students work in group rather than individually.

The collaborative learning of students in ICT-assisted mathematics classroom is more meaningful when we understand its historical context. Historical study shows that one of the earliest forms of technology 'slate board' that developed later as 'blackboard' was used in the classroom in the 1830s (Mehlinger, 1995). Similarly, the electronic media such as radio and film appeared in the 1930s and the technologies like tape recorder, language laboratories, television and videos have been used since 1960s and 1970s (Poudel, 2020). The extensive rise of emerging ICT and its capability in providing all human beings to overcome the barriers caused by distance, time and location has created conditions for preferred use of these tools in human actions (Alberts & Papp, 1997). In this 21st century knowledge society, ICTs are the leading forces for determining human actions and interactions in which creation, dissemination and utilization of information and knowledge is at center for all economic and social activities (Crede & Mansell, 1998). This type of development of

technology made knowledge and information accessible to anyone, anytime and anywhere that has boosted ICT use as it facilitates all formal, informal, and non-formal settings of learning through E-learning, M-learning, virtual learning (VL) or open and distance learning (ODL) (Drigas & Tsilaki, 2015). In this way, the historical trends for shifting learning opportunity for engaged and collaborative ICT learning is helpful for making a paradigm shift from traditional chalk-talk method to ICT-supported pedagogy.

The students' perceptions suggest that the role of teachers in technological age is to provide essential skills for learners to be adjusted in the techno-based rapidly expanding knowledge society. To achieve this goal, ICT-based instruction is essential to produce and use knowledge for individual and social development. ICTs have potentials to connect an individual and a society to the wealth of information and expertise (UNESCO, 2015). With teachers' primary role, technology helps students to get access to information by empowering each individual to create, disseminate and consume information and knowledge. Access to information and knowledge is essential for individual development as it enables the users to be empowered by providing knowledge resources (UNESCO, 2015). In this way, the teacher can play a pivotal role in assisting students to choose appropriate ICT tools in solving mathematical problems.

Students opined that technology plays crucial role in daily lives of people in general and on their educational activities of every learner. The proper use of technologies enables students to have access to world knowledge resources, share resource materials with others in the field of mathematics. With the use of technologies, it is possible to connect isolated classrooms to the rest of the world (Perez & O'Neil, 2003). Technologies helps students by providing better learning

opportunities, help teachers to change their teaching strategies and methods to make them learner-centered and guide all members of academic community by facilitating to exchange the information (Clyde & Delohery, 2005). Therefore, technology makes easier for both resources and procedures for learning mathematics.

Specifically, the analysis of students' perceptions informed that there is no significant difference between the perception of students with their gender, discipline, level and location but there is significant difference between the perception of students towards the input, implementation and output of ICTIP in higher education mathematics classes. Several researchers (e.g., Aiken, 1970, 1976; Eleftherios et al., 2007) have shown that students' attitude towards mathematics is associated with their achievement. In a study report, Eleftherios et al. (2007) reported that there was no significant statistical difference between female and male students concerning the factors; mathematical understanding through procedures and studying mathematics with understanding. They also found that female students have a stronger belief that mathematical understanding is achieved through these procedures than male students do. Their study further reported that female students study mathematics more carefully than their male peers. This result aligns with the finding of the present study.

The findings from students' data have shown that students used different web browsers and emails on their laptops, tablets, and mobile phones for finding necessary resources for updating their knowledge and collecting instructional materials. The students accessed information, learning resources and knowledge using mainly the tools web-browsers, emails, LMSs, YouTube, Facebook, WhatsApp, Viber, Skype/chat, etc. Based on the experiences of teachers' and students' and my own observation during the study, it can be concluded that there were many remarkable changes to access the information using technology than the traditional methods. The

Internet was used to visit the world's libraries for e-books, e-journals, database and that the web-sites in the web-browsers such as YouTube, Google Scholar and Facebook were used for collecting required learning resources and information.

The opinion of students shows that use of ICTs and integration into pedagogical practices had brought changes in the ways that they accessed information and resources, carried out collaborative learning activities, and learned mathematics in such a way that those activities became faster, easier, and enjoyable to help knowledge construction. The findings also revealed that students have positive perceptions towards the input, implementation and output of ICTIP in teaching learning process. The results further indicated that all the statements are significant and there is consistency between the perception of students on the input, implementation and output of ICT-integrated pedagogy adopted by the teachers. The perception of students towards the practices of ICTIP revealed that the ways students used to search resources do not depend on the gender of the students, location of the campus they attend, and the level of the program students enrolled. The students who have easy access to technology and ICT devices used more and advanced resources to search learning resources. The students who do not have such access got help from their friends. Likewise, the time devoted by the students in their mathematics learning using ICT does not depend on gender, level, discipline of the students and location of the campuses. These findings echo the conclusions made in the USA by Chuban (2019) that there is no significant difference between the perceptions of students by their gender in relation to the use of ICT. The students who frequently used a number of digital resources in their learning process have similar perceptions despite the fact that there are variations on input of digital resources in different constituent campuses of TU. In this way, students' perceptions informed that the

students who use limited number of ICT resources can be benefitted as others if they are dedicated to their learning.

Comparison of Students' Perceptions

One of the objectives of this study was to compare the perceptions of students on the practices of ICTIP in higher mathematics classes. For this purpose, the perceptions of students were collected through questionnaire with 240 sample students selected from 12 constituent campuses of TU. To achieve this objective a research question was formulated to compare the perceptions of students towards the implementation of ICT integrated pedagogy based on their institution and gender.

The students of higher education mathematics classes perceived ICT integrated pedagogical practices more beneficial and supportive on their learning than the traditional methods of teaching. Use of technology enabled teachers and the students to bring the outer world into the classroom. The technology integrated pedagogy facilitated learners for practical activities and conceptual learning. According to Kislenko, Grevholm and Lepik (2005), students' perception towards mathematics teaching and learning play important role in teaching learning activities and the student's perception towards mathematics is positive and the proper use of ICT helps to visualize abstract concept of mathematics. The finding of this research is similar to the finding of my research that the perception of the students towards the practice of ICTIP is positive. This research also concludes that there is no significant difference between the perception of students in terms of their gender, discipline, level and location but the difference is significant on the input, implementation and output towards the practices of ICTIP in higher mathematics classes. The findings have also informed that there is no significant difference between the perceptions of the students not using ICT tools, time spent by the students on their study using ICT

and number of resources used by the students for searching their study materials. ICT integrated pedagogy is useful for the teachers for preparing their lessons, delivering their lessons, increasing the learners' motivation and interaction, and providing the learners with learning resources and feedback.

The comparison of students' perceptions on the basis of different constructs of input, implementations and output of ICTIP shows that there is significant difference between the perception of students towards the input, implementations and output, but the difference was not significant between the perceptions of boys and girls in terms of input of academic environment, curriculum integration, human resources, and digital resources to implement ICTIP for delivering mathematical contents. Likewise, there is no significant difference between the perceptions of boys and girls towards the opportunity and challenges of ICTIP, assessment and evaluation process and inter and intra communication on their institutions. However, there is no significant difference between the perceptions of boys and girls students on regularity of classes, management of teachers and other resources and pedagogical process to implement ICTIP on higher mathematics classes. Additionally, there is no significant difference between the perceptions of boys and girls on the increment of students' achievement, shift in pedagogy, impact on policy, change on attitude and pedagogical transformation due to the implement ICTIP on higher mathematics classes but the difference was found significant towards the outcome in the society and equity promotion after the implementation of ICTIP in teaching mathematics.

The comparison of students' perceptions about the practices of using ICT tools and using different resources reveals that there is no significant difference between the perceptions of students using up to three ICT tools, up to six ICT tools, up to nine ICT tools and more than nine ICT tools to learn mathematics. This also informed that

there is no significant difference between the perception of students who spent less than one hour, one to two hours, two to three hours, three to four hours and more than four hours to learn mathematics each day. Likewise, there is no significant difference between perception of students who use one resource, two resources, three resources and four resources to access information, reading materials, searching assignment or task in their mathematics learning. The finding of the research conclude that there is no significant difference between the perceptions of students on regularity of classes, management of teachers and other resources and pedagogical process to implement ICTIP on higher mathematics classes.

Relation between Different Constructs on the Input, Implementation and Output of ICT for the Practices of ICTIP

The correlation between different constructs on the input, implementation and output for the practices of ICTIP shows that the assessment and evaluation is directly related with the intra and inter communication between the students and teachers, and the academic environment of the institutions directly related with the infrastructure of the related institutions. This relation also shows that the assessment and evaluation is directly related to the intra and inter communication between the students and teachers and the shift in pedagogy on teaching learning process directly related with student's achievement. This study concluded high correlation between the input and implementation of ICTIP whereas low correlation between input and output. Likewise there is no significant relationship between students' activities for accessing information, resources, assignment/task and different variables viz. caste, gender, academic level, discipline and location of campuses. This suggests that although the mathematical classroom in higher education is highly heterogenous in terms of caste, gender and location, this difference does not make any impact on the ways ICT

information and resources are accessed and used by various groups of students. This is an encouraging finding that shows the demographic variations have no role to play to have access to ICT resources in mathematics classroom.

There is positive correlation between the perceptions of students on input, implementation and output of ICTIP applied by the teachers in their mathematics classes. There is high correlation between input and implementation of ICTIP and the correlation is low between input and output of ICTIP. Likewise, there is high positive correlation on the perception of students between infrastructure and academic environment and low correlation between human resource and digital resource. The correlation was found high positive between the constructs assessment and evaluation, and intra and inter communication but low between opportunity and challenges and regularity on the basis of students' perception towards the practices of ICTIP. Similarly, there is high correlation on the perception of students between impact on policy and shift in pedagogy. This indicates that better policy implementation in educational institutions helps to shift pedagogical process over the period of time.

The students' data informed that there is no correlation between the perceptions of students with faculty and location of campuses and faculty and level about the practices of ICTIP. There is negative correlation between the perception of students on the basis of gender and caste, gender and faculty, gender and level and gender and location. Likewise, there is negative correlation between perception of students on the basis of caste and location, level and caste and level and location but very low correlation between caste and faculty and caste and level towards the practices of ICTIP. These findings relate to the findings reported by.....where...

Impact of Students' General Practices and Input on the Output of ICTIP

The study deals with the connection between the five constructs of input for ICTIP and its output (Appendix A). The constructs of input includes input on human resources, digital resources, infrastructure, academic environment and ICT integrated curriculum. The result shows that there is positive impact of input on output of ICTIP. The total of 17.7% of the variance in output of ICTIP can be explained by the combined effect of input on human resources, digital resources, infrastructure, academic environment and ICT-integrated curriculum as respond by the students. The results conclude that the provision of class regularity, good classroom management, appropriate pedagogical process, regular intra and inter communication with students and regular assessment and evaluation results better output on students achievement. The results also shows there is significant impact of better management, ICT-based pedagogical process and intra and inter communication in the output of ICTIP. Likewise, the variable, the number of hours spent in learning mathematics and practices of accessing resources has positive impact on the better output of ICTIP whereas number of ICT tools used by the students has negative impact on the perception of students towards the output of ICTIP. The more ICT tools practiced by the students got more engaged on time but the perceptions of students reveals that the more engagement on ICT tools is no only the causes for better output of mathematics. This indicates that the students who were involved in group discussion and active involvement in learning have better achievement in mathematics.

Teachers' Experiences towards the Practices of ICTIP

The ICT integrated instruction basically made the class student-centered in which students' enthusiasm and curiosity facilitated their learning. Additionally, they found that their students' achievement comparatively increased after it. It essentially

reflects the findings that digitally skilled students are much adaptive and adoptive towards technology than those who are migrants having less digital skills (Prensky, 2012). Some teachers observed some exceptional progress in their students along with additional energy, excitement, interest while they were taught through visualization in the ICT lab/class. Thus, this finding also confirms the finding of Shapley et al. (2010) that ICT integrated instruction increases learners' creativity and autonomous learning. The use of ICT in the field of education has itself student-centered learning settings and often this creates some misconception on the role of teachers and students. But with the world moving towards digital media and information, the role of ICT in education is becoming very important and this importance will continue to grow and develop in the 21st century learning skill.

The strategies of teachers to integrate technology into their pedagogical practices were mostly confined to the basic usage of technological tools (computer, laptop, mobile, graphic tablet, graphic calculator, Bluetooth) and the internet. The practices of ICT-based pedagogy saves teachers' labor and time. In the literature, it is mentioned that using ICT in teaching mathematics can help teachers to express clearly what they want to express to the class and students understand what the teachers have expressed through the demonstration, visualization and experimentation (Pangani, 2013). This techno-pedagogy connection draws on the principles of connectivism that creates networking opportunities among teachers and students to learn the course contents (Siemons, 2005). As this view, the present study finding shows that using mathematical software and other audio-visual resources in mathematics class creates fun learning among students, enhances interaction among them and draws their attention towards learning.

It was found in the study that the teachers have positive perceptions towards ICT integrated pedagogical practices, and believe that ICT assisted in accessing information, collaborative learning, promoting equity and developing transformation in pedagogical practices. The findings also reveal that the teachers and students were not satisfied with the infrastructure developed by the institutions to integrate ICT into their pedagogical practices. Majority of the students were mostly dependent on their teachers for accessing learning resources and information. Likewise, more than 80% of the respondent teachers had not got proper training about the pedagogical practices of ICT tools and mathematical software and that they were not confident of productive utilization of ICT tools in teaching-learning process. The main factors for their low confidence were the poor ICT infrastructure, insufficient pedagogical skills due to the inadequate ICT-related trainings and workshops, limited technological skills of the teachers and the students, and traditional curriculum and textbooks. Likewise, due to geographical difficulties and resource constraints, Nepalese educational institutions are unable to manage appropriate learning resources in the classrooms. This leads to demotivate students as well as teachers towards adopting new dimension in teaching learning even though they are very much curious and optimistic towards effective implementations of ICTIP.

On the other hand, as teachers suggest, there are different students having different interests due to individual difference and the teacher can choose the best strategies to manage such variations. This relates to what Duke, Harper and Johnston (2013) mentioned about Connectivism that offers the specific technological opportunities for the learners to be actively involved in the presentation of a body of knowledge. Further, it can be an alternative learning strategy which states that learner attempt to foster understanding connecting between specialized communities

(Siemons, 2005). The view of teachers is same as the findings of Ghosh, Hattangdi and Atonu (2007) that ICT can enhance greater collaboration between the pupils as it helps to increase students' motivation towards teaching. Integrating ICT also facilitates teachers to produce, manipulate and communicate the information for students with different learning abilities. It helps in collecting, storing, processing, researching, transferring and uploading the information connected to the teaching and learning processes as well as planning to enhance the quality of education. It equally helps in creating an enjoyable teaching-learning environment. One of the purposes to introduce ICT in education is the pedagogical aspect where the pedagogical rationales are to utilize technology in enhancing learning, flexibility and efficiency in curriculum delivery.

However, my observation also reveals that, practices of ICT integrated pedagogy in mathematics classes have brought change in the educational activities of TU. At present, the traditional chalk and talk teaching and learning has been replaced by powerpoint presentation and that has increased the students' motivation and has assisted their permanent learning. ICTs have created the environment for exchanging more information and ideas, enhancing interaction and discussion, increasing the accessibility of resources, and providing more amount of exposure to the teachers and students. However, the productive utilization of ICT integrated instructional practices is required and needs close attention. The TU authority need to think seriously to improve the infrastructures, organize ICT trainings for the teachers, and to revise the curriculum and textbooks for better improvement of ICT integrated pedagogy in higher mathematics classes.

The findings on the mathematics teachers' lived experiences of integrating ICT into their pedagogical practices showed that they have positive perceptions and

are convinced towards the benefits of integrating ICT into their pedagogical practices. ICTIP helped them to motivate students towards learning and increased interest in learning abstract concepts of mathematics such as limit, derivative, antiderivative, conic section, affine plane, projective plane, and three dimensional concepts, among others. ICT tools can facilitate teaching and learning activities if they are used properly. The dynamic features of digital technology permit teachers and students to create a virtual network of colleagues where they can discuss learning issues and share ideas. The students and teachers' acceptance of the technology contributes towards promoting more collaborative learning opportunities among them (Davis, 1989). It helps to solve the problems or difficulties of students in understanding some subject matters immediately, and they don't need to wait for another day. Most of the sample teachers have been practicing this type of pedagogy for some years and some of them started it during pandemic when the online classes were implemented. It also concluded that all of the participant teachers were well-motivated and experienced but they did not practiced as expected as they lacked professional skills on putting technology-integrated approach to classroom practice. Beside these, it was found that teachers practiced social constructivist and connectivism learning theory into their pedagogical practices where technology integrated instruction promoted student-centered learning and connecting the technology as a means of pedagogy to deliver prescribed contents. Thus, the lived experiences of respondent teachers teaching with ICT integrated pedagogy were very impressive in the sense that they were highly positive and excited in using them. In the section below, I briefly present some strategies used by teachers in integrating ICT into pedagogy, their experiences towards the access of technology, impact of ICTIP on students and teachers' practices and benefits of ICT tools for mathematics teaching.

Teachers' Strategies of Integrating ICTIP

The university level teachers used some ICT tools and applications in their pedagogical practices. Evidently, the findings show that they used the general applications of ICT, i.e. word office software, PowerPoint, Animation, and Edvi software. Additionally, they used YouTube, and Google search for downloading the required audio/video materials and typing difficult mathematical symbols in their class either using multimedia/projector or whiteboard. Likewise, they used Graphic calculators, graphic tablet and Latex to type different mathematical symbols and equations. Furthermore, teachers used different mathematical software such as Mathematica, GeoGebra, C programming, SPSS, Excel and Maple for ICT integrated pedagogical practices. The strategies that they followed were to display the downloaded content materials (textual, audio and video) related to the course searching from the Internet and YouTube. Similarly, they were found to have incorporated the course related audios/videos into their PowerPoint presentation slides. Additionally, some teachers used Moodle platform for uploading reading materials, applying as discussion forum and a forum to submit assignment. Moreover, some teachers utilized social networking sites such as Facebook, Messenger group, Viber, Personal mail and WhatsApp to get connected with their students that helped them facilitate their students for learning beyond the classroom space and time. During the pandemic period, teachers used Zoom, Google classroom and MS Teams to launch online classes. But only making technology available in their classroom and providing essential ICT training for teachers cannot assure the effective integration of the technology in pedagogy (Rana & Rana, 2020).

Though there are some models/frameworks for integrating ICT into instructional practices (as reviewed in Chapter Two, the TPACK model by Mishra

and Koehler, 2006), some of the sample teachers (only seven) were found to be aware of the above model/strategy of integrating technology into their pedagogical practices. However, their strategies to integrate ICT tools into pedagogical practices followed flip pedagogy and student centric learning strategies. Moreover, this finding is line with principles of social constructivism theory (Vygotsky, 1978) and connectivism theory (Siemens, 2005). As these theories described and also found in this study, the students actively participated in ICT integrated classes and teachers used technology as a means of pedagogy through networking to deliver mathematical contents.

Teachers' Experiences of Impact on Classes

The findings on the impact of ICT integrated pedagogy on the mathematics classes brought the fact that the teachers found some differences on the motivation of students and collaboration between them after the practices of ICTIP. They realized that their students' attention increased in learning and were very creative (Cagiltay, Ozcelik & Ozcelik 2015; Hwang & Chen, 2016) that saved their time and facilitated instruction. It also helped increase students' achievement (Tuzun et al., 2009).

Moreover, the ICT integrated pedagogical practices made the class student-centered in which students' remained active and curious to learn. Additionally, the interview with teachers shows that their students got comparatively better achievement after the implementation of ICTIP. Their views reflected that digitally competent students also supported their teachers to launch online classes and to use mathematical software on mathematics teaching. Some teachers observed students' creativity in their project presentations. Moreover, the students were found to be collaborating with their peers, be critical and excited while they were taught through visualization in online classes. Thus, this finding also confirms the finding of Shapley et al. (2010) that ICT integrated instruction increases learners' creativity and

autonomous learning. One of the mathematics teachers (i.e., T₉) found that some of his students seemed far competent on technological knowledge and skills than him. They assisted to manage technology during the classroom instruction. It reflects that teachers come from diverse educational backgrounds and therefore their exposure to and competency in using digital resources varies (also see, Ashrafzadeh & Sayadian, 2015; Prensky, 2012). The view of teachers reveals that there is paradigm shift in the role of teachers', i.e. 'the decentralization of the teachers' that helps to promote students' ability to construct their own knowledge independently but with partial guidance of teachers (Vygotsky, 1978). The theoretical perspectives of social constructivism and connectivism put emphasis on technology as a medium of instruction that facilitates student-centered learning. Similarly, the construction of knowledge through collaboration and cooperation will certainly lead them towards self-learning. However, teacher's role as a guide could be meaningful because Vygotsky's idea of the more knowledgeable other (MKO) still plays a vital role.

The teachers who are connectivist pedagogues connect technology-based pedagogy to teach mathematical contents through student-centered approaches (Tam, 2000). Thus, teachers require expertise in terms of having knowledge and skills of integrating ICT into their instructional practice that priorities the role of mathematics teachers (BECTA, 2004; Mishra & Koehler, 2006). In the similar vein, the study found that the teachers' knowledge and skills for the effective implementation of ICT integrated pedagogy is very important. Additionally, it was also found that teachers were competent in using word processor, PowerPoint, Google search, and YouTube but they seemed incompetent to use mathematical software such as Mathematica, GeoGebra, C programming, SPSS, Excel and Maple in their classes. Having inadequate training exposure in ICT affected their pedagogical practices so that they

could not use ICTs as competently as expected, which was also found during their classroom observation and interviews.

Teachers' Experiences on Institutional Support and Policy Development

The finding in terms of institutional support for ICT resources and application is not sufficient. For example, as teachers shared, a very few teachers got chance to participate in workshops and training programs to develop their skills in ICT integrated pedagogy. During the pandemic, TU decided to run the classes of Bachelor's and Master's level on online mode and issued online class guideline and electronic communication management guideline for the proper management of online classes. Many constituent and affiliated campuses of TU developed infrastructure as well as learning environment for online mode of teaching. Teachers and students were trained for this situation. This research found conflicting views among teachers regarding the support they obtained from their campus administration. They also expressed dissatisfaction in the policy decisions made at the university level. Even though, the institution has resources, due to unwillingness of authority to create favourable environment, the ICT tools and other resources have not been effectively used in pedagogical practices.

Some campus administration authorities supported teachers and provided them with the required ICT infrastructures. On the contrary, some teachers expressed bitter experiences that their campus administration discouraged them in the practices of ICT integrated pedagogy rather prioritized the traditional methods of learning. This indicates that there is a gap between ICT policies and the classroom reality in the use of ICT in higher education. Although the educational policy in ICT emphasizes the integration of digital technology in teacher education including in-service teacher training (MoE, 2013), there is no clear strategy of TU and the government to equip

the universities with ICT infrastructure and to train university teachers and administrative staffs how to use digital technologies properly (Rana & Rana, 2020).

Opportunity and Challenges of ICT Integrated Pedagogical Practices

The challenges faced by teachers to integrate ICT in instruction include inadequate ICT training, low institutional support, lack of dedicated internet, lack of genuine mathematical software, resource limitations and unreliable power supply. These challenges have been organized in categories such as access, policy and practice that are crucial to the university teachers in integrating technology in their pedagogy (Khan et al., 2012; Nyambane & Nzuki, 2014). Teachers' inability to use ICT effectively might have been caused by their limited competences and motivation. In this regard, Khokhar, Gulab and Javaid (2017) state that mostly teachers in developing countries lack the competences and motivation to integrate ICT into their pedagogical practices as they are not well prepared for such instructional practices. On the contrary, in my study, I found that the teachers were devoted and motivated as they voluntarily integrated ICT into their instructional practices even though they lacked proper ICT training.

To make a breakthrough in information, knowledge and communication, ICTs are the powerful tools (Rabah, 2015). These ICT tools help to acquire the skills needed for the 21st century knowledge society where many fields such as media, education, and commerce have been more technology-dependent. The integration of ICT in the field of education has been a common objective globally and Nepal is not an exception. ICT integration in education prepares individuals to use technologies in constructive ways and to be knowledgeable and technologically competent to meet the demands of the evolving job market (Ozdemir, 2017; Rabah, 2015). However, research studies have found that there are several challenges towards ICT integrated

pedagogical practices. The challenges of integrating ICT in pedagogical practices are: lack of supporting leadership, inconsistent investments in ICT equipment, infrastructure and resources, inflexibility of funding, limited professional development opportunities and support, and incorporation of technology in evaluation and curricular plans (Rabah, 2015).

In the same way, Ozdemir (2017) highlights inadequacy of technology infrastructure, ICT inadequacy of the teacher and students, inadequacy and unsuitable course materials as the challenges of ICT integration. As Ozdemir and Rabha mentioned, the challenges that I found from this research are; inadequate ICT training for technology mediated teaching, low willingness of institutions, inadequate ICT infrastructure at campus, lack of incentives, traditional curriculum and rigid structure, lack of technical human resource, weak policy implementation, limited institutional support, lack of dedicated internet and unreliable electricity facility, and lack of genuine mathematical software and other resources for ICT integrated instruction. Likewise, in the context of Tribhuvan University, the lack of clear educational policy in ICT, strategic document and institutional plan are found to be major initial problems to integrate ICTIP effectively. The limited ICT infrastructure and teachers' poor ICT knowledge and skills have also impacted the expected practice of available digital technology effectively.

Beside these challenges, the opportunities of ICT integrated pedagogy are; ICTIP develops conceptual understanding, it helps for concept formation, creation, and visualization of abstract contents, it makes easy access on resources as well as share own ideas globally. ICT helps to develop the global village of the learners' community, it helps to develop awareness on media and online skills, and reduces fear in teachers and students. The ICT infrastructure enables teachers and students to get

exposed to the up-to-date knowledge of methods of instruction. It further contributes on students-centered learning, improved self-motivation, meaningful learning and conceptual clarity.

Likewise, ICT connects each people to the source of knowledge. ICT helps teachers to teach subject matters differently and effectively. It also helps them to prepare classes as per the psychology of the students. ICTIP enables them to conduct mass teaching (same class delivery for all students), knowledge triangulation and authentication. ICT integrated pedagogical practices create equitable learning conditions in the classroom and help them make pedagogical transformation through improving students creativity, self-reflection, critical awareness and collaborative practice. Likewise, other opportunities in using ICT include - ICT as motivating factor, a tool for any time any-where learning, and means to develop creativity and collaboration. It has also been used as one of the primary modes of instruction during and after the Covid-19 pandemic, and can be an alternative mode in case of any potential crisis in the future.

Inadequate Professional Training

It was found that Mathematics teachers in particular lacked professional training to integrate ICT effectively into their pedagogical practices. In the absence of professional training, they apply basic ICT knowledge and skills for teaching abstract mathematical concepts like three dimensional concepts, topological equivalence, projectivity, limit, continuity, etc. The teachers' low level of ICT knowledge and skills seemed to be hurdles to effective implementation of the available ICT resources in teacher education. The report of 2019 Digital Nepal Framework also shows that insufficient training of teachers leads to high absenteeism and low student engagement and motivation on classroom (MoCIT, 2019). Nevertheless, lack of

sufficient technology skills of teachers caused their low level of ICT use in the classroom (Rana & Rana, 2020). The underdeveloped infrastructure and facilities at both rural and urban institutions, including lack of learning materials and equipment further heightened this demotivation. Teachers simply download mathematical content- related to audio/video materials from the Internet, YouTube, Google scholar that they visualize in the class. Additionally, they frequently use some social networking sites such as Facebook and WhatsApp, Messenger group, Viber, personal mail in order to facilitate their students.

Demotivation

Some of the teachers aged around 60 years and retirement time in TU service were demotivated to integrate ICT into their pedagogical practices. Likewise, the time and resource constraints and lack of administrative support also demotivated teachers to apply ICTIP. In this regard, Groff and Mouza (2008) assure among four categories of influential factors in ICT integration, the context (college) is one. Thus, the context of the campus where the teachers work plays a vital role in terms of the colleagues/peers support available for the practices of ICT integrated pedagogy. On the contrary, some of the teachers face their colleague's discouraging comments for their activities to integrate ICT into the instruction. Additionally, lack of time hinders teachers to integrate technology into their practices (Digedu, 2014).

Inadequate ICT Infrastructure and Internet Facility

The teachers encounter constraints in resources or infrastructure at campus that includes the lack of “technology, poor bandwidth internet, electricity, classroom setting...and technical support” (Hew & Brush, 2007, p. 226). Furthermore, “a lack of hardware, poor organization of resources, poor quality hardware, inappropriate software, and lack of personal access by teachers are other problems” (BECTA, 2004,

p. 14) are some of the other challenges. Similar to this, the constituent campuses of TU, Nepal were reported to be under-resource for ICT integrated instruction. Similar to this, some previous research studies (Jaschik & Lederman, 2013; Young, 2012) found that the lack of incentives in the form of professional training for teachers, support for device, reward with promotions, etc. hindered technology integration by teachers in teaching mathematics.

Digital Divide Among Students

There are some challenges students faced that included lack of ICT experience and skills, negative attitudes and beliefs towards the use of ICT (Groff & Mouza, 2008). On the contrary, the participants in this study reported that their students were positive and interested to learn mathematics using ICT tools and mathematics software. The digital divide existed among students that affected their learning using ICT integrated pedagogy. Some students reported that they had the ICT devices, while others said they still do not have such devices. This created an opportunity gap among students. All of my participant teachers informed that lack of access to ICT devices at campus and at home made them uninterested to assign any task to the students that required students to use ICT. Teacher's experiences show that in some cases a whole family of some students depend on a single mobile as ICT device and some of them depend on their relatives or public office for internet connection.

From the above observation, I argue that although students and teachers are generally positive towards the use of ICT, there is variation in the opportunities among students based on their gender, location, and level. This unequal access provided some students better opportunities while other may further remain behind.

Lack of Technicians

My observation as well as information obtained from the teachers, there is lack of ICT technician for fixing ICT problems in all selected campuses. The participants said that in case of problems in the ICT devices, they cannot get the problems fixed instantly due to lack of ICT technician at their institution. Moreover, the participants are not professionally well trained and they have no time for fixing technology problems with the support of colleagues in their assigned time table. Thus, lack of ICT technicians at educational institutions hampers the teachers from integration of ICT into their instruction. Similarly, Khan et al. (2012) found that lack of provision of technical resources, technical assistance from technicians including some other factors demotivated teachers to integrate ICT into their pedagogical practices.

Lack of Appropriate Software for Mathematics

The experience of teachers with their class observation reveals that they were found to be aware of specific websites and mathematical software but they lacked access to those apps. Thus, they were confined to searching and downloading the free content materials, i.e. audio/video using google search and YouTube. This is not encouraging for teachers to integrate ICT into their pedagogical practices (Andoh, 2012). Additionally, some of the participants were unknown of those mathematical software and sites even though there are many free mathematical software and sites for resources to teach mathematics effectively.

Traditional Curriculum and Rigid Structure

Restrictive and traditional curriculum, rigid structure of educational systems, backup of the administrators, etc. (Andoh, 2012) are challenges for integrating ICT into instruction. The teachers at the constituent campuses of TU are bound to struggle

for effective integration of ICT into their pedagogical practices due to the traditional curriculum. They shared their experiences that the Mathematics curriculum/courses require drastic change for integrating ICT into instruction. Though the ‘ICT policy 2010’ brought several policies to update the mode of instruction, it did not completely revise the mathematics curriculum of university level to facilitate the teachers for integrating ICT in their instruction. This lack of revision in the traditional and structured curriculum/course has created challenges to them.

Weak Policy Implementation to Integrate ICT

The findings of the research conclude that there is rigid policy and traditional thinking of administrators hampered the integration of ICT into instruction. The administrators thought that the integration of ICT in pedagogy is not compulsory. Some teachers do it voluntarily whereas the other teachers who got chance to participate in the training or workshop on ICT integration conducted by different NGOs/INGOs use ICT tools in teaching. They mentioned that although the ICT use policies exist in institutions, implementation of them is still not satisfactory. He means to say that the implementation or execution of those rules, regulations and policies is not focused into practice to implement ICTIP. This informed that there is weak policy implementation for integrating ICT in their pedagogical practices.

Opportunities

On the basis of interpretation of the data and my personal experiences, some of the major opportunities towards the practices of ICTIP in higher mathematics classes are presented below.

Anytime Anywhere Learning

One of the major opportunities of ICT-based instruction is anytime anywhere learning opportunity for students. ICT provides both online and blended learning

environments that will be helpful to connect home, campus and other spaces anytime anywhere whenever required (Downes, 2005). This study also suggests that the ICT integrated teaching is making the learning space accessible anytime anywhere through online classes and using MOODLE platform. The online classes and technology integrated classes are helpful to enhance teaching and learning hours beyond F2F and school/campus boundaries in the form of anytime anywhere learning space (Rosen & Nelson, 2008). It is important when it is needed so that learners get the opportunity to improve learning in time (Hung & Khine, 2006). The above literature with my findings mentioned that online and blended learning environment can create flexible learning opportunities to provide learning resource, feedback and support and formative assessment. Similar findings are justified in a study conducted by Kaplan and Haenlein (2009). Overall, multiple learning resources and their engagement in discussion forums help learners to connect with their teachers and colleagues in their comfortable time and space.

Developing Creativity and Collaboration

Making collaborative learning easier is one of the significant benefits of ICT use in mathematics classroom. As also suggested by Atan (2012), ICT integrated pedagogy applied by the teachers helps all students for collaborative work and activate their learning. It gives opportunity for interaction with friends that makes learning process effective. There is collaboration between students, students-teachers, and teachers by sharing their experiences, problems, teaching strategies, materials and innovative ideas using different communication platforms like Messenger, Zoom, Teams, Viber, etc.

The experiences of teachers also revealed that they utilized ICTIP for making their presentation attractive and resourceful in mathematics classroom. They also

utilize interactive media for sharing the progress while conducting the tasks or assignments as the collaborative activities. Advocating the importance of ICT integrated pedagogy for creativity and collaboration, one of the students S₂ expressed his view during FGD as “...the major role of ICTIP to enhance learning are; to change the way of learning, to be creative, to develop self-learning environment, to make learning practicable using learning by searching and to solve the problems quickly.” The view of the student concludes that ICTIP helps the students for collaborative work and activates them for interaction providing equal opportunity for each individual. The students took benefits from ICTIP in their collaborative learning activities. In my observed classes the students were given the group works and project works related to their textbook exercises and the course contents and to solve the given tasks the students were involved in collaborative activities and group interactions. The students utilized the ICT tools such as laptops, mobile phones, email, Facebook, Messenger, Google classroom and WhatsApp for utilizing collaborative activities to complete the given tasks. Collaborative learning can be facilitated by using ICT technologies including virtual classrooms, online discussion boards, and collaborative software. Under a social constructivist approach, students can collaborate, have group discussions on mathematical ideas, and solve problems as a group. This creates an atmosphere in which students create meaning by interacting with one another, sharing ideas, and expanding comprehension.

ICT as a Motivating Factor

The use of ICT in mathematics classes motivates students towards learning because ICT helps teachers to visualize the abstract mathematical concepts practically and it makes the learning permanent. The remarks expressed by the participant teacher also support this view. He said, “Using ICT tools students actively

participated in mathematics classes because they learn mathematics differently and practically. ICT helps students with easy access to learning materials and it helps for permanent learning on students.” So, ICT in learning mathematics increases students’ interest and joy in mathematics (Tossavainen & Faarinen, 2019). This indicates that students were highly motivated towards ICT due to intrinsic motivation followed by extrinsic motivation.

ICTIP as a Means of Pedagogical Transformation

The experiences of teachers reveals that ICTIP played a crucial role for pedagogical transformation. There is drastic change in teaching-learning process using ICTIP by changing the dimension of teaching with encouraging students for self-learning. ICT makes changes in the behavior of teachers and the traditional mindset of teachers in pedagogical process changes due to technology. The pedagogical transformation empowers learners to engage in collaboration to co-construct meaning from ICT-based media and materials and experiences through an inquiry-based approach. Supporting these views, the findings of the researchers (Komolafe et al., 2020) reveals that teachers and learners in higher institutions have interest, engagement and active participation on online classes that enhance learning experience as well as promote good learning outcomes in learners. Social constructivism promotes students to use online networks and resources to participate in mathematical debates, exchange ideas, and ask for assistance. Online tools can help people collaborate and communicate outside the classroom, enhancing the social component of education and giving students access to a range of viewpoints. This discussion shows that the ICTIP is used as an alternative medium of instruction and it is used as a means of pedagogical transformation.

Medium of Instruction During and After COVID 19 Pandemic

The increment of teachers' confidence on teaching using technology during the pandemic is remarkable. The practices of ICT integrated pedagogy at university mathematics classes of TU is still found at the initial stage. The majority of teachers of TU were unknown about the use of technology for online teaching at the initial stage of the pandemic. This crisis became an opportunity to learn and use technology in teaching learning process. Still, the changes brought by the COVID-19 pandemic created opportunity to practice ICT integration in teaching and learning in all levels (Akram, et al., 2022). This means, although teachers had a very critical time during the early phase of the pandemic, with a fear of the pandemic, they took this crisis as an opportunity to equip themselves with technological skills and used them through online teaching as a best alternative of physical teaching. A gradual shift in learning of ICTs and their application boosted their confidence and they became enthusiastic and hopeful for bringing further innovation and change in their traditional teaching (Khanal, 2020). The experiences of teachers show that COVID 19 pandemic brings not only the problem but also the opportunity to use alternative mode of instruction in our educational system. The next benefit of using ICT is, needy students can easily communicate with their teachers on their comfortable time and media. Teachers and students during and after COVID 19 used ICT as an alternative way of instruction.

Promoting Equity in the Class

Although ICT divides the students on the basis of the access to equipments and opportunities, the teachers found ICT applications significant for providing equitable opportunities for learning among students with varied learning abilities. In particular, ICT provides an opportunity for the needy students to consult and share their problems in a comfortable time, and teachers easily address their problems.

ICTIP is an easily accessible medium of instruction for weak students for self-learning and it is a good platform for them to communicate with their teachers when they need help in the subject matter. In my observed classes, I also found that teachers create equal opportunity for all students and try to reduce the biasness. In addition, there is no personal discrimination in the class when the teachers use ICT tools in their instruction. Beside this, they give students the chances to put personal queries and encourage them for discussion. Similarly, Powell (1994) reported that equity means each student will be addressed as an individual, with instructional opportunities, content, and approaches that meet their specific needs, strengths and interests.

Flipped Pedagogy: As an Alternative Strategy

The use of technology in higher education mathematics classes changes the traditional learning setting by providing instructional materials online beyond the classroom premises. The use of ICTIP is also found contributory to apply flipped methods in teaching. As a form of blended learning, flipped pedagogy provides necessary materials for students on the previous days of the allocated class, students watch online lectures or required videos, collaborate in online discussions, or carry out research at home and engage in the concepts in the classroom with the guidance of a mentor. The flipped classroom on mathematics contents have positive impact on students' achievement (Ramakrishnan & Johnsi, 2016). In a conventional classroom teachers teach the allocated class on a set period for their students but flipped mastery classrooms follow a mastery learning approach where students fully understand their unit topic before progressing to the next one.

Flipped pedagogy increases the harmony between students in the classroom and makes the students more engaged in the classroom through discussion using

online learning platform. The use of flip pedagogy in mathematics classes provides students a chance to reflect on their ideas at the beginning of the class. The teachers can provide group work, pair work, and individual presentations opportunities to the students and the course can be completed on time. Likewise, in these pedagogical practices, students can explore and examine these simulations together in a social constructivist setting, sharing their findings and conclusions. This innovative method also makes learning more meaningful and interesting by assisting students in connecting mathematical ideas to real-world situations.

Chapter Seven

Conclusion and Implications

In this chapter, I have summarized the major findings reported in Chapters Four, Five, Six and Seven. Conclusions have been drawn based on the findings. Following the conclusion, implications and suggestions for future research have been presented.

Conclusion

This study contributes to the field of ICT-based mathematics pedagogy focusing on Nepal's university level classroom. Considering students' perceptions, I derived four major conclusions. Firstly, while students are largely positive towards the practices of ICT-based pedagogy, there are variations in perceptions in terms of gender, location, discipline, and level of enrollment. Based on the study's purpose of exploring the experiences of teachers and perceptions of students towards ICT integrated pedagogical practices in higher education mathematics classes of TU, several key findings and conclusions have emerged. The teachers and students who have practiced ICT integrated pedagogy in their class for learning mathematics have positive perceptions. They have strong belief on the use of ICT tools for accessing information, being independent on learning, promoting equity and developing transformation in pedagogical practices even though they were not competent in the practices of ICT tools and mathematical software for productive utilization on teaching-learning process.

The analysis of quantitative data concludes that there is positive relationship between input, implementation and output. However, there is no good outcome and implementation of ICTIP as the input in constituent campuses of TU is still inadequate. If there is good inter and intra communication between students and

teachers and shift in pedagogy then it will positively affect the students' achievement. Likewise, the perception of students does not differ significantly by their gender, discipline, location of campus, and enrolled level but the significant difference was found in the input of ICT resources, implementation status and output from the ICT integrated pedagogical practices.

The teachers and students have positive perceptions towards ICT-integrated pedagogical practices and believe that ICT integrated pedagogy assisted teachers and students in accessing information, and making independent learning. There is low correlation between input of ICT integrated pedagogy and its implementation in real classroom. This study also concludes that there is inadequate implementation of ICT integrated pedagogy in mathematics classroom. However, there exists improved output than desired input. The result shows that there is positive impact of input and implementation on output of ICTIP. The total of 17.7% of the variance in output of ICTIP can be explained by the combined effect of input on human resources, digital resources, infrastructure, academic environment and ICT-integrated curriculum as responded by the students. Likewise, the variable, the number of hours spent in learning mathematics and practices of accessing resources has positive impact on the better output of ICTIP whereas number of ICT tools used by the students has negative impact on the perception of students towards the output of ICTIP.

ICT integrated pedagogical practices helps in accessing information, collaborative learning, promoting equity and developing transformation in pedagogical practices. The findings also reveal that the teachers and students were not satisfied with the infrastructure developed by the institutions to integrate ICT into their pedagogical practices. Majority of the students were mostly dependent on their teachers for accessing learning resources and information. The main factors causing

this condition was inadequate ICT infrastructure development, insufficient pedagogical skills due to the lack of ICT-related trainings and workshops, poor technological skills of the teachers and the students, and continuation in the use of traditional curriculum and textbooks. Likewise, due to geographical difficulties and resource constraints, Nepalese educational institutions are unable to manage appropriate learning resources in classrooms. This leads towards demotivation of students as well as teachers in adopting new dimension in teaching and learning even though they are curious and optimistic in relation to the effective implementation of ICTIP.

ICT-based pedagogy facilitates collaborative learning involving teachers and students in virtual classrooms, online discussion, and use collaborative software to have things done. This creates an atmosphere in which students make meaning by interacting with one another, sharing ideas, and expanding one another's level of content comprehension. Besides this, ICT tools can help students collaborate and communicate outside the classroom, enhancing the social component of education and giving students access to a range of viewpoints. Under a social constructivist approach, students can collaborate, engage in group discussions on mathematical ideas, and solve problems related to mathematics learning through peer teaching. Peer teaching fosters a social and collaborative learning environment by allowing peers to learn from numerous perspectives by reinforcing their own understanding. The use of ICT offers a range of tools for simulating mathematical problems and modeling real-world settings. Students can investigate and examine these simulations together in a social constructivist setting, sharing their findings and conclusions. This innovative method makes learning more meaningful and interesting by assisting students in connecting mathematical ideas to real-world situations. The study also revealed that

ICT integrated pedagogical practices facilitated the teachers and students to access information and resources, carrying out collaborative learning, and so on. The use of ICT in education can therefore foster effective learning through face-to-face as well as distance engagement of the students and teachers. Thus, this study concluded that ICT integration in educational activities is needed, and it is to be more systematized in Nepal's higher education institutions, so that students coming to higher education can learn more flexibly across their time and spaces.

Implications of the Study

This convergent parallel mixed methods research aimed at exploring the experiences of teachers and perceptions of students towards the practices of ICT integrated mathematics pedagogy in higher education. The knowledge constructed through the lived experiences of the teachers is subjective and context specific (Christensen et al., 2010) that gives meaning to their practice of ICT integrated pedagogy at higher level mathematics classes. Likewise, the perception of students is objective which was measured through quantitative analysis. Thus, an in-depth exploration of teachers' lived experiences and perceptions of students towards the teachers' efforts with researcher's observation have essentially unfolded the realities on the practices of ICT integrated pedagogy and the challenges in effective implementation of ICTIP. Therefore, the conclusions drawn on the basis of the findings suggest some prominent implications potentially useful for future actions.

Implications for Executing Policies

It is highly required to execute all the policies that have been designed to upgrade the ICT knowledge and skills of the teachers and students at TU campuses. Further to this is the need to upgrade the curriculum to support students to learn the most recent knowledge and skills in ICT. Though it is mandatory to integrate ICT into

instructional practices in all levels of education (MOE, 2013), in reality, it is voluntarily done by some teachers through their own initiatives. It shows that there is a gap between the policies and their execution. It is also equally important for all the stakeholders of the constituent campuses of TU, the UGC Nepal and Nepal government to play key roles to make higher education competitive and updated by integration of most recent technology in teaching and learning. Additionally, the TU authority and the line agencies including the administration of the constituent campuses should collaborate and collectively develop a strong and reliable mechanism to institutionalize the use of technology in higher education. While some policies are in place, their successful implementation requires systemic intervention, which the authorities have to be aware of and responsible for execution. As there is an exponential growth of internet users in Nepal (as per the Nepal Telecommunications Authority data, 250 new users added every hour), the university authorities should be able to catch up with this trend by expanding the ICT use in educational practices. Establishment of e-libraries in campuses and a centralized control mechanism for access to the university owned resources would benefit not only the teachers and students, but also the staff. ICT use not only be the part of teaching, rather it must be a holistic approach for the overall development of the university and the quality of higher education. In that, digitalization of every material of university and campus with high-speed internet facilities and modern quality technology is the most important first step for integrating ICT in the education process.

Implications for Campus Administration

Basically, it is crucial to provide adequate ICT infrastructure to higher education institutions for launching online classes as well as to fulfill the need of 21st century education. The only one ICT lab available in some colleges makes teachers

wait for 1-2 weeks to get their turn to use it. This situation discouraged the teachers to use ICT resources in teaching. Additionally, in most cases, students could not use ICT devices while being taught in the ICT lab. They were bound to practice using pen and paper during the ICT integrated instruction due to lack of sufficient ICT devices. In such cases, only teachers used ICT and students followed them using pen and paper. Moreover, the digital divide that exists among the students of the constituent campuses of TU is also attached to the availability of ICT infrastructure. Therefore, the concerned institutions should be provided with sufficient ICT infrastructure along with well-equipped ICT classrooms, to enable teachers to integrate ICT into their pedagogical practices any time they need. The concerned authorities need to deploy high-density networks at urban colleges and university campuses to support the uninterrupted running of devices, IT tools, and applications and use of wireless and satellite technologies to connect institutions' IT infrastructure in hard-to-reach remote areas. Beside this, it would also reduce the barrier of time constraint for learning and communication.

Implications for ICT Training

The teachers are highly determined to bring change into their instructional practices through the practices of ICTIP. So far, they have put their effort into it using the basic knowledge and skills of ICT, they learnt personally by practicing it or supported by some friends. Nevertheless, they require some expertise in terms of integrating ICT for instructional practices. They are primarily in the great need of ICT training for effective implementation of mathematical software including drawing and animation.

The modules of these trainings should essentially incorporate some well-designed frameworks/models such the TPACK model. These frameworks especially

guide teachers for technological knowledge and skills in terms of pedagogical practices. Additionally, the TPACK model is crucially required to every teacher. Because their pedagogical content knowledge (PCK) alone does not help them for technology integrated instruction, rather they need to be able to understand the ways of effective integration of technological, content and pedagogical knowledge in their lessons. Therefore, it is necessary to empower the teachers by strengthening and supporting them in using technology in a professional manner in designing and delivering their lessons. They should be provided with continuous professional development opportunities, short-term and long-term, so that teachers can integrate the most recent technology in their pedagogical practices.

Implications for Equality among Teachers

One of the findings of this study was about the lack of incentives for permanent and temporary teachers which made them discouraged in using ICT. The campus administration seemed, in most cases, unwilling to support technology integration, and that further discouraged teachers to do so. This might have been because the campuses do not have sufficient financial strength in managing their infrastructure techno-friendly. Consequently, the teachers realized a sense of demotivation instead of getting support in using ICT in their pedagogical practices. This is an exceptional finding of the present study. Additionally, though it is mandatory to do technology integrated instructional practices according to the 'ICT Policy in Education 2010' (MOE, 2013), the institutions have not been able to make it mandatory due to the insufficient infrastructure available in the campuses. Therefore, teachers who have used ICT in teaching require incentives either in the form of praising, rewarding, honoring or promoting so that it contributes towards bringing a positive impact on their practices.

Implication for Promoting Equity and Pedagogical Transformation

The findings of the study reveal that ICT integrated pedagogical practices in mathematical classes in higher education helps to promote equity in learning, which could therefore be a means of pedagogical transformation. As this study reported that teachers did not get equal access to resources, though limited, provision for supporting teachers with equal opportunities to use the ICT resources in their teaching and learning is to be established as a regular part of the professional practice, and it can be enabled through planned professional development support for teachers.

Limitations

The current research was limited in some ways. First, the study took longer time than I had planned. Due to the Coronavirus pandemic, both the 2019-2020 and 2020-2021 academic years were badly affected. During the time, the sampled campuses were partially opened, but could not run the classes physically. The classes were run virtually, although several technical issues were faced. In this context, the data could not be collected as scheduled. So, the interview of eight teachers, FGD with students and four classes observations were conducted online using Zoom and MS Teams.

Second, because of the same reason, I changed two sample teachers and twenty five sample students. Even in the post-pandemic period, people from outside the concerned places, like me, were not easily allowed to take interviews and conduct survey. Likewise, after having modified the plan proposed in my PhD proposal viva, I fixed only two disciplines, viz. Education and Science only in my sample.

The third limitation of the present study was that I could not revisit all the teacher participants for the purpose of member checking to maintain the trustworthiness of the research. I utilized this strategy by taking transcribed data,

which were collected in the Nepali language, and their interpretations back to only six of the interviewed participants involved in the study. This helped me understand whether or not their meaning was reflected in the data I transcribed and in the interpretation I made.

The limitations mentioned above and some other constraints beyond my control taught me some lessons that I came to know that the research plan should be prepared with careful and minute observations of everything to minimize such limitations in the process of research.

Future Directions

The findings in this study have specified several obstacles that hindered the effective integration of technology in teaching learning process including lack of resources, limited leadership support, accessibility constraints in ICT infrastructure, inadequate time, unclear policies, lack of professional development training and lack of appropriate pedagogical models. In this context, the concerned authorities should work on the needs and gap which hinder educational practices from effective technology integration to acquire maximum benefits from technology integrated teaching and learning. The Government of Nepal needs to launch compulsory IT education for colleges to develop digital skill on teachers and students and systematically strengthen Nepal's education system to impart advanced ICT education all over the country. To realize the considerable technical and financial challenges, the concerned authority needs to setup educational facilities and digital infrastructure in as per the specific contexts of the educational institutions across the country.

The role of campus administration and university authority is crucial in formulation of appropriate policies and promoting ICT integrated pedagogical practices. At college, the role of Campus Chief/ Head of Department is very important

for launching ICTIP into the classes. Their leadership to make the institutions technologically rich not only encourages teachers to integrate technology into their pedagogical practices but also enhances their digital knowledge and skills (Chang, 2012). Their support is vital for the teachers; therefore, further research studies are required for examining the influences of administrator's perceptions and beliefs on ICT integrated pedagogical practices.

This study confirms that there exists a digital divide among students of constituent campuses of TU. As a result, those students who have ICT access at their home could practice and become competent users of technology whereas those who do not have such access could not use ICT tools properly. This type of digital divide and its impact may be seen in future in terms of skilled and unskilled manpower, that also links to their employability skills required for future job markets. Thus, it could be an area of further research. Additionally, the effectiveness of technology integration model such as TPACK model and Technology Acceptance Model model could be the areas of further extensive research.

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Appendix A: Questionnaires for Student's Perceptions

Dear Students, This Questionnaire form is presented to you as a research tool for collecting information about ICT integrated pedagogy to the purpose of my Ph D study entitled 'Practice of ICT Integrated Pedagogy (ICTIP) in Higher Mathematics Classes: A Mixed Methods Approach'. This questionnaire form will try to explore the feeling of students about practice of ICT integrated pedagogy in mathematics class by your teacher. It will take about 25 minutes to read and complete the questionnaire form. There is no such right and wrong answer. The decision to the respective statements is based on your own opinion.

Your name and the name of your organization are optional. All the information collected through the reflection form will be kept confidential and will not be used for any purpose other than the research. Please feel free while filling out the reflection form. Your participation is voluntary and if you decide not to take part, you are still free to withdraw at any stage.

If you have any queries regarding the reflection or research, please do not hesitate to talk with me.

Thanking you for your kind cooperation.

Lok Nath Bhattarai

Ph D Scholar

Graduate School of Education, FoE, TU

Personal details

Name: Gender.....

Name of the Campus: Caste/Ethnicity.....

Faculty: Level:

1. General Practices of information and communication technology (ICT) in learning mathematics.

(a) Do you use any ICT tools to learn Mathematical concepts? Tick (✓) in the box.

Yes No

(b) What ICT tools do you use for learning Mathematics? Please tick (✓) in the multiple boxes if you use two or more tools of the following.

Mobile phone Laptop/computer

Computerized information system (CIS) CD ROM

Tablet Interactive whiteboard Multimedia projector

TV Radio Telephone

Offline software programmes LMS platform such as Moodle

Mathematical Software

Internet assisted software tools (You tube, Face book, E-mail, Google docs, Wiki, Imo, Viber, Skype, Web sites e)

(c) On the average, how many hours do you spend on learning Mathematics using ICTs each day?

Less than 1 hour 1 to 2 hours

2 to 3 hours 3 to 4 hours

More than 4 hours

d) On the average, how much of your time spent on using ICTs in Mathematics?

0 % between 1% to 25%

between 26% to 50% between 51% to 75%

between 76% to 100%

2. ICTs for accessing information

(a) How do you mostly access the information/resources? Please tick (✓) in the multiple boxes if two or more activities of the following are applicable in your case.

(i) I use ICTs tools such as laptop, radio, mobile phone, TV, Tablet, CDs, and software tools such as You tube, Email, Wiki, Blog, Facebook, Google search

(ii) I use library (iii) I consult the teachers

(iv) I consult my friends

(b) How and where do you find textbook related resources, assignments, or tasks?

Please tick (✓) in the multiple boxes if two or more categories of the following are applicable in your case.

(i) I find them in LMS or while searching using ICTs

(ii) I find them in the library

(iii) I note down when our teacher informs them in the classroom

(iv) I consult my friends for such things

3. Perception of students towards input of ICT integrated pedagogy (ICTIP)

S.N.	Statements	SA	A	U	DA	SD
	Infrastructure					
a.	We have equipped classroom with sufficient spaces and fixed multimedia projector.					
b.	Our institution develops ICT lab with sufficient computers.					
c.	Technical support from administration to develop ICT friendly environment is necessary.					
d.	Our institution provides necessary materials to integrate ICT in learning mathematics.					

	Human resource					
e.	There is availability of experienced teachers to use ICT tools and techniques, but we are not skilled in ICT					
f.	Teachers feel more stressed but responsible and accountable to students teaching and learning through ICT integrated pedagogy (ICTIP)					
g.	Our teachers are competent to organize and manage students' learning tasks through ICTIP					
h.	ICT will upgrade teacher's role making it more substantial					
i.	There is lack of technical support regarding ICT integration					
	Digital resource	DU	FU	RU	SU	NU
j.	We can use sufficient digital resources (i.e. smart board, e-library, mathematical software) in our college.					
k.	High quality e-content creation and internet facility is available for students and teachers in our college.					
l.	Our university develops a versatile and easy affordable digital device at the earliest.					
	Academic environment					
m.	There is peaceful and lovely environment with co-operative teachers and staffs in our college.					
n.	There is provision of regular and interactive classes with resource materials for students.					
o.	We feel proud to our institution for student friendly					

	environment and rich library facility.					
	Curriculum integration					
P	We can easily use ICTIP on various content of mathematics.					
q.	Authority was not interested to develop ICT based curriculum.					
r.	The syllabus/text books are supportive for learning with ICTIP					
s.	Curriculum does not allow enough time to integrate ICT in teaching					

(SA: Strongly Agree, A: Agree, U: Undecided, DA: Disagree, SDA: Strongly Disagree)

(DU: Daily Used, FU: Frequently Used, SU: Sometime Used, RU: Rarely Used, NU: Not Used)

4: Perception of students towards implementations of ICT integrated pedagogy

S.N.	Statements	A	U	G	O	R
	Regularity					
a.	Our teachers use ICTIP in Mathematics class.					
b.	The high quality internet and necessary mathematical software facility are available for students.					
c.	All the courses of mathematics are completed on allocated time frame integrating ICT.					
	Management					
d.	ICT integrated pedagogy is impressive but cannot contribute					

	substantially to teaching and learning in diverse classes					
e.	The classroom management of teachers is appreciable using ICTIP.					
	Pedagogical process					
f.	The ICT integrated pedagogy would contribute to increase necessary competencies on students compare to the traditional approach					
g.	Teachers use ICT integrated pedagogy effectively in our mathematics classroom					
h.	The frequency of student's interactions increases through ICT integrated pedagogy.					
i.	ICT integrated pedagogy provides a space where learning can take place independently that makes learning easier.					
	Intra and inter communication	A	U	G	O	R
j..	ICT integrated pedagogy makes communication more convenient.					
k.	We participate in discussion, group work to utilize the ICT tools such as google docs, email, Facebook, Skype, Wiki with our teachers.					
l.	ICT integrated pedagogy increases interaction and motivation on learning mathematics.					
	Assessment and evaluation					
m.	We use different ICT tools and techniques to prepare project work, field work, seminar and assignments.					
n.	All the assignment and examinations were submitted on Moodle					

	or email through online mode.					
	Opportunities and Challenges					
o.	There are several problems to implement ICT integrated pedagogy due to time constraints.					
p.	There are challenges to implement the ICT integrated pedagogy					
q.	The teaching-learning in your campus are interrupted because of some technological problems					
r.	ICTIP is not affordable for students due to lack of financial or academic support from institution.					

[A=(always= you use them for more than 88% of your study time), U=(usually=you use them for 67% to 88% of your study time), G= (generally= for 45% to 66% of your study time), O= (often= for 23% to 44% of your study time), R = (rarely= for up to 22% of your study time)]

5. Perception of students towards output of ICT integrated pedagogy

S.N.	Statements	SA	A	U	DA	SDA
	Students achievement					
a.	The average achievement of students increases after the implementation of ICTIP					
b	Application of ICT has made my understanding conceptual					
d	I believe that ICT integrated pedagogy contribute on students learning because it makes student active					
	Shift in pedagogy					
d.	There is a pedagogical shift from conventional teaching approach to ICT integrated pedagogy					

e.	I believe that ICT integrated pedagogy is useful for teachers' as well as students to visualize abstract mathematical concepts clearly					
f.	I believe that ICT integrated pedagogy can help students' critical thinking.					
Outcome in the society						
g.	The ICTIP is useful in higher mathematics classes because it will prevail in the future society					
h.	The ICT integrated pedagogy is useful for mathematical reasoning and concept development.					
i.	I believe that ICT integrated pedagogy helps us to be critical in thinking					
Impact on policy						
j.	I believe that textbooks' preferential role in education will be replaced by new media based on ICT					
k.	I believe that the teacher's role should be radically changed in future years because of ICT					
l.	ICT reduces teachers role which may negatively effect in students education					
m.	I believe that the role of educational institutions will be radically changed in future years because of ICT					
n.	ICT integrated pedagogy produces new models for teaching and learning.					
Change on attitude						

o.	I believe that the role of educational institutions will be radically changed in future years because of ICT					
	ICT integrated pedagogy produces new models for teaching and learning					
	ICT integrated pedagogy can be a best strategy for teaching and learning every content of mathematics					
	Promoting Equity					
p.	The ICTIP is helpful for applying culturally responsive skills of actively engaging students, using real world examples, assessing your learning other than tests, cooperative learning, and non-authoritarian styles of classroom management					
q.	For creating equitable learning opportunities in class, massive increase in meaning centered learning opportunity and critical focus on mathematics is needed.					
r.	Through ICT integrated pedagogy we students from different culture, different socioeconomic status and different level of learning can learn math equally.					
s.	The ICTIP create equitable environment in higher mathematics class.					
	Pedagogical Transformation					
t.	ICT helps us for easy access for learning mathematics in pandemic period of time.					
u.	ICTIP increases the students' creativity and helps to					

	develop meaning centered activities.					
v.	There is critical focus on every content of mathematics through ICTIP that makes the teaching learning process natural.					
w.	ICTIP make the teaching learning process meaningful and contextual.					
x.	The ICTIP is the best ways for pedagogical transformation in the digital era.					

[EU=(extremely useful=you use them for more than 88% of the activities of your Mathematics study), VU= (very useful=you usually use them (for 67% to 88% of the activities of your Mathematics study)), U= (useful=you most often use them (for 45% to 66% of the activities of your Mathematics study)), S= (satisfactory=you often use them (for 23% to 44% of the activities of your Mathematics study)), NS= (no satisfactory=you rarely use them (for less than 23% of the activities of your Mathematics study))]

6. What is the role of ICT Integrated Pedagogy (ICTIP) in enhancing your access of information/resources in your higher mathematics study? Please give your opinion in brief.

.....

7. Does ICTIP provide meaning centered learning opportunity and critical focus on mathematics?

.....

8. How do ICTIP help you for carrying out your collaborative work/activities?

.....

9. What ICT tools/software do you use for visualizing abstract concepts of mathematics?

10. How do ICTIP play role for creating equitable learning opportunities in class and help for pedagogical transformation?
.....

11. What problems and challenges do you encounter regarding the integration of ICT in solving higher mathematical problems?
.....

12. What are your suggestions for effective implementation of ICTIP in higher mathematics classroom?
.....

Thank You

Appendix B: Interview Guideline for Teachers

Access on Technology

1. ICT tools/ Mathematical software available in your Institution/ classroom.
2. What type of ICT tools and mathematical software do you use in your class?
3. Techniques followed to make abstract mathematical concepts understandable.
4. Digital resources (i.e. smart board, e-library, mathematical software) and internet facility in your college.
4. Experiences on the implementation of ICT integrated pedagogy for subject you taught.

Motivating Factors

1. ‘Technology integrated learning can better prepare students for the 21st century’ why?
2. Motivating factors to use ICTIP.
3. Mathematical software in your class.
4. Strategies use to motivate and encourage students to use ICT tools.

Teacher Preparedness

1. Did you provide sufficient examples, models, or experiences for their successful implementation of ICTIP?
2. How do you know when to use mathematical software/ ICT tools?
3. How do you incorporate technology integrated pedagogy/ mathematical software into your instruction?

Teacher Strategies

1. Your experience in teaching higher mathematical concepts through ICT integrated pedagogy.
2. How did you make the mathematical concepts understandable to students?

3. What strategies you used? Why did you use these strategies? Any reasons?
4. Particular attributes/characteristics of the students when teaching by ICT integration.
5. What do you think that ICT integrated pedagogy is a best strategy for active participation of students? How effectively do you think it could facilitate mathematics learning?

Creativity and Collaboration

1. How much creative did you have to integrate ICT in your class?
2. Ways that you have been able to use technology to enhance student learning.
3. Encourage for collaboration and creative thinking in your class. If so, how?

Criticality and Co-operation

1. How are students using ICT tools and mathematical software in learning mathematics?
2. How often do you check student progress?
3. What are some ways you have helped students by using technology as a learning tool?
4. ICT tools and mathematical software used by students at home.
5. What strategies do you use to keep students engaged?
6. In what extent the technology integrated pedagogy helps to create equitable environment in higher mathematics class?
7. Your experiences about the pedagogical transformation through ICTIP in pandemic period?

Opportunity and Challenges

1. What do you feel about the challenges in teaching mathematics at university level?
2. What is the role of ICTIP (if any) to overcome these challenges?

3. How would you describe the use of ICTIP in pandemic period due to COVID-19?
4. What do you think about the future direction of ICT integrated pedagogy in higher study of mathematics?

Change Management

1. Did you apply culturally responsive skills of actively engaging your students, using real world examples, assessing learning in ways other than tests, cooperative learning, and non-authoritarian styles of classroom management?
2. What instructional or management strategies do you use to integrate technology in your classroom?
3. What is the role of ICTIP for equity and pedagogical transformation?
4. How did you implement ICTIP on building prior knowledge, critical consciousness and sharing of power?

Appendix C: FGD Guideline for Students

- What is the role of ICT Integrated Pedagogy (ICTIP) in enhancing your access of information /resources in your higher mathematics study? Please give your opinion in brief.
- Does ICTIP provide meaning centered learning opportunity and critical focus on mathematics?
- How do ICTIP help you for carrying out your collaborative work/activities?
- What problems and challenges do you encounter regarding the integration of ICT in solving higher mathematical problems?
- What are your suggestions for effective implementation of ICTIP in higher mathematics classroom?
- What ICT tools/software do you use for visualizing abstract concepts of mathematics?

Appendix D: Class Observation Protocol

College:

Class Teacher:

Lesson/Topic:

Date:

Stages of activities	Teacher's activities	Students' activities	ICTs/other tools used	Observation remarks
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Warming up

Presentation

Practice of ICT IP

Evaluation

Conclusion

Homework

Other remarks

Appendix E: Details of Teacher Participants

SN	Teacher	Gender	Qualification	Faculty	Experiences	Teaching level	Location	Remarks
1	T ₁	Male	M Ed	Education	16 years	B Ed	Out of valley	Lecturer
2	T ₂	Female	M Phil	Education	14 years	M Ed	Within valley	Lecturer
3	T ₃	Male	Ph D	Education	30 years	M Ed	Within valley	Professor
4	T ₄	Male	M Sc	Science	12 years	M Sc	Within valley	Lecturer
5	T ₅	Male	M Phil	Education	6 years	M Ed	Out of valley	Lecturer
6	T ₆	Male	M Ed	Education	6 years	B Ed	Out of valley	Teaching Assist
7	T ₇	Male	Ph D	Science	18 years	M Sc	Out of valley	Reader
8	T ₈	Male	M Ed	Education	19 years	B Ed	Within valley	Lecturer
9	T ₉	Male	M Ed	Education	10 years	B Ed	Out of valley	Lecturer
10	T ₁₀	Male	M Sc	Science	8 years	B Sc	Within valley	Teaching Assist
11	T ₁₁	Male	Ph D	Science	26 years	M Sc	Out of valley	Reader
12	T ₁₂	Female	M Ed	Education	14 years	M Ed	Out of valley	Lecturer
13	T ₁₃	Male	M Sc	Science	20 years	M Sc	Out of valley	Lecturer
14	T ₁₄	Male	M Ed	Education	12 years	B Ed	Out of valley	Lecturer

Appendix F: List of the Sample College

1. Central Department of Education M. Ed.
2. Mahendra Ratna Campus, Kathmandu B.Ed.
3. Sanothimi Campus, Kathmandu M. Ed./ B. Ed.
4. Gorkha Campus, Gorkha M. Ed. / B. Ed
5. Prithivi Narayan Campus, Pokhara M Ed.
6. Butwal Multiple Campus, Butwal B. Ed
7. Thakurram Campus, Birjung B. Ed
8. Mahendraratna Campus, Ilam B. Ed
9. Central Department of Mathematics M. Sc.
10. Trichandra Campus, Kathmandu B. Sc.
11. Patan Multiple Campus, Lalitpur B. Sc.
12. Prithivi Narayan Campus, Pokhara M Sc. /B.Sc.
13. Post Graduate Campus, Biratnagar M Sc.
14. Ramsworup Ramsagar Campus, Janakpur B. Sc./ M. Sc.

Appendix G: Coding the data with ATLAS.ti. on ICTIP promotes equity

ID	Codes	Quotation Content	Basic theme	Global theme
2:62	Equal opportunity for all students	When we use ICT tools and mathematical software in our class there is equal opportunity for all students.	ICTIP promotes equity	
2:85	There are no personal discriminations when using ICTIP	ICT help for creating equal opportunity in mathematics classes and reduces the biasness of teachers toward the students. There is no chance for personal discrimination in class when a teacher uses ICT tools and techniques in his classes.	ICTIP address the individual differences.	
2:125	Increasing Teachers-students' collaboration	There is equal treatment for each student using ICT and the needy students can easily communicate and raised their problems with teachers using ICT.	ICTIP promotes collaboration	
2:192	ICT creates equitable learning environment	All the needy students share their problems with teachers besides the formal class through different medium and equally benefitted from teachers. This creates an equitable learning environment in the class, which promote the equity pedagogy.	ICTIP promotes equity in classes	
2:213	ICTIP promotes equity	ICT is a milestone for maintaining equity by giving abstract concepts of	ICTIP promotes	

		mathematics in an easy way for weak students.	equity in classes	
2:285	There is no discrimination in ICT classes	Equity means unequal treatment for equality. ICT provides an opportunity for the needy students to consult their teachers about their confusion in a comfortable time, and teachers easily address their problems. ICT is an easily accessible medium of instruction for weak students for self-learning and it is a good platform for communication with their teachers as their need.	ICTIP promotes equity in classes	ICTIP promotes equity
2:310	Unequal treatments for equality	Yes, ICT helps to promote equity pedagogy in mathematics classes. In my experience, the disadvantaged group of students also benefited from ICT-based classes.	ICTIP promotes equity	
2:327	Unequal treatments for equality	ICT helps to promote equity pedagogy in mathematics classes. There is an opportunity for needy students to contact with their teachers personally.	ICTIP address the individual differences.	

Appendix H: Coding the data with ATLAS.ti.on ICT as a motivating factor

ID	Codes	Quotation Content	Basic theme	Global theme
2:53	ICT as motivating factor	We generally use the conventional method to teach mathematics on higher level. It was not possible to give clear concepts with simple manipulative materials. The ICT tools and software were used as motivating factor when I was a student at M Phil.	Motivating Factors for using ICTIP	
2:184	Visualizing abstract mathematical concepts	ICT helps teachers to visualize the abstract mathematical concepts practically and it makes the learning permanent. Mathematics and ICT are inseparable disciplines.	Motivating Factors for using ICTIP	
2:204	Visualizing abstract mathematical concepts	Neither ICT can develop without mathematics nor mathematics can sustain without ICT. ICT helps for motivating students and teachers toward new concepts of mathematics.	ICTIP helps for motivation	
2:223	ICTIP develop academic environment.	ICT helps to develop an academic environment in mathematics classes. The students were happy in ICT classes and were motivated toward mathematics due to ICTIP.	ICTIP helps for motivation	ICT as a motivating factor

2:252	ICT for easy access on resources	ICT helps students with easy access to learning materials and they have the opportunity to learn mathematics practically.	ICT for practical learning.
2:270	ICT for permanent learning	ICT helps teachers to give mathematical concepts clearly and it helps for permanent learning on students.	ICT for creativity and independence
2:296	ICT helps students to be creative and independent.	Using ICT tools students actively participated in mathematics classes because they learn mathematics differently and practically. ICT helps students and teachers to expose on the global village.	ICT for practical learning.
2:326	ICT helps students to be creative and independent.	During pandemic we learn several things through technology and technology helps each individual to be independent and creative.	ICT for creativity and independence

Appendix I: Coding the data segment with ATLAS.ti. on ICT as a change agent

ID	Code	Quotation Content	Basic theme	Global theme
2:67	ICT for visualization and manipulation	There is an improvement in the field of education through ICTIP. ICT tools are used as a change agent in mathematics learning.	ICT as a change agent on education	
2:74	ICT for visualization and manipulation.	I am fully convinced and satisfied with ICT tools and believe that it helps to visualize the abstract concept of mathematics. The students get chances to manipulate and visualize the mathematical problems through ICT.	ICT as a change agent on education	
2:87	ICT as a means to improve achievement	It has a positive role to improve students' achievement. So, we can take ICTIP as a change agent in the process of teaching-learning advanced concepts of mathematics.	ICT as a means of change	
2:186	ICTIP for live and behavioral learning	We can deliver more mathematical content using technology-based pedagogy than the conventional method of teaching. ICT makes the teaching live and more behavioral.	ICT as a means of change	
2:241	ICTIP promote the student	There is an interaction between students and teachers in ICT integrated classes and students	ICT changes the paradigm of	ICTIP as change agent

	dominant class activity	actively participate in the classes. After using ICTIP in mathematics classes we change our mindset and sharpen ourselves. We change the teaching paradigm through student dominant activity in the class.	education
2:358	ICTIP transform the learning system.	ICTIP changes the modality of teaching-learning drastically so, it is taken as change agent in the field of education. Using different ICT tools in learning mathematics, it transforms the work performance of teachers and students.	ICT changes the paradigm of education
2:360	ICT for paperless learning	ICT is a change agent in the process of teaching-learning because it creates a paperless environment and easy access to resources.	ICT changes the paradigm of education
2:41	ICTIP transform the learning system.	The students who have no access on textbooks during the pandemic benefitted from ICT. They have easy access on learning resource due to ICT.	ICT for paperless learning
2:357	ICT for paperless learning	After the innovation of ICT, our teaching-learning process becomes paperless and device-less. The documentation process of a large file is very easy due to ICT	ICT as a medium for paperless learning

Appendix K: Coding the data segment with ATLAS.ti. on ICTIP as a means of pedagogical transformation

ID	Codes	Quotation Content	Basic themes	Global themes
2:61	ICTIP helps for shifting pedagogy	ICT helps for shifting pedagogy and allows self-learning and motivation. ICT changes the modality of teaching at higher level.	ICTIP help for pedagogical transformation	
2:86	Pedagogical transformation is the main function of ICTIP.	We use students centered teaching in mathematics class through ICT tools and software. ICT helps to shift the conventional teaching methods to the recent teaching methods.	ICTIP help for pedagogical transformation	
2:109	ICIP changes dimensions of education	ICT helps to change the dimension of teaching by encouraging all students on learning. ICT helps to search new materials and makes the students independent.	ICTIP for pedagogical transformation	Pedagogical transformation through ICTIP
2:119	ICIP changes the	ICT makes changes in our behavior and teaching	ICTIP changes the	

	dimensions of education	process. The teaching-learning process is drastically changed through ICT and it is a milestone for pedagogical transformation.	dimension of teaching learning
2:144	The learning modality drastically changes	ICTIP promotes learning by doing skill and make conceptual clarity. The change in the behavior leads the means of pedagogical transformation.	ICTIP changes the dimension of teaching learning
2:178	ICTIP for pedagogical transformation	Hence ICTIP helps for the pedagogical transformation.	ICTIP promotes criticality
2:196	ICT makes students creative	In developed countries, ICT is used as the medium of delivering content and concept development. During this pandemic period, there is a pedagogical shift in our teaching-learning process using ICTIP.	ICTIP promotes criticality

2:214 ICTIP helps The achievement of ICTIP
to increase students increases after promotes
achievement implementing ICTIP. This cooperation
of students leads to the pedagogical
transformation on the
teaching-learning process.

Appendix K: Reliability Statistics of Input for ICTIP

Statements	Standard Deviation	Cronbach's alpha
We have equipped classroom with sufficient spaces and fixed multimedia projector	0.640	0.918
Our institution develops ICT lab with sufficient computers	0.935	0.921
Technical support from administration to develop ICT friendly environment is necessary	0.528	0.918
Our institution provides necessary materials to integrate ICT in learning mathematics	1.224	0.917
There is availability of experienced teachers to use ICT tools and techniques, but we are not skilled in ICT	1.162	0.922
Teachers feel more stressed but responsible and accountable to students teaching and learning through ICT integrated pedagogy	0.750	0.918
Our teachers are competent to organize and manage students' learning tasks through ICTIP	0.796	0.918
There is lack of technical support regarding ICT integration	0.958	0.919
ICT will upgrade teacher's role making it more substantial	1.086	0.918
We can use sufficient digital resources (i.e. smart board, e-library, mathematical software) in our college	1.181	0.919
High quality e-content creation and internet facility is available for students and teachers in our college	1.097	0.917
Our university develop a versatile and easy affordable digital device at the earliest	0.958	0.917
There is peaceful and lovely environment with co-operative teachers and staffs in our college	0.976	0.917
There is provision of regular and interactive classes with resource	0.959	0.917

materials for students

We feel proud to our institution for student friendly environment and rich library facility	1.008	0.917
We can easily use ICTIP on various content of mathematics	0.959	0.915
Authority were not interested to develop ICT based curriculum	1.090	0.921
The syllabus/text books are supportive for learning with ICTIP	1.057	0.917
Curriculum does not allow enough time to integrate ICT in teaching	1.307	0.921

Appendix L: Reliability Statistics of Implementation of ICTIP

Statements	Standard Deviation	Cronbach's alpha
Our teachers use ICTIP in Mathematics class	0.790	0.915
The high-quality internet and necessary mathematical software facility are available for students	1.098	0.914
All the courses of mathematics are completed on allocated time frame integrating ICT	1.120	0.914
ICT integrated pedagogy is impressive but cannot contribute substantially to teaching and learning in diverse classes	0.926	0.914
The classroom management of teachers are appreciable using ICTIP	0.752	0.916
The ICT integrated pedagogy would contribute to increase necessary competencies on students compare to the traditional approach	0.752	0.917
Teachers use ICT integrated pedagogy effectively in our mathematics classroom	0.945	0.916
The frequency of students' interactions increases through ICT integrated pedagogy	1.049	0.917
ICT integrated pedagogy provides a space where learning can take place independently that makes learning easier	1.057	0.917
ICT integrated pedagogy makes communication more convenient	1.151	0.914
We participate in discussion, group work to utilize the ICT tools such as google docs, email, Facebook, Skype, Wiki with our teachers	0.868	0.915
ICT integrated pedagogy increases interaction and motivation	1.037	0.915

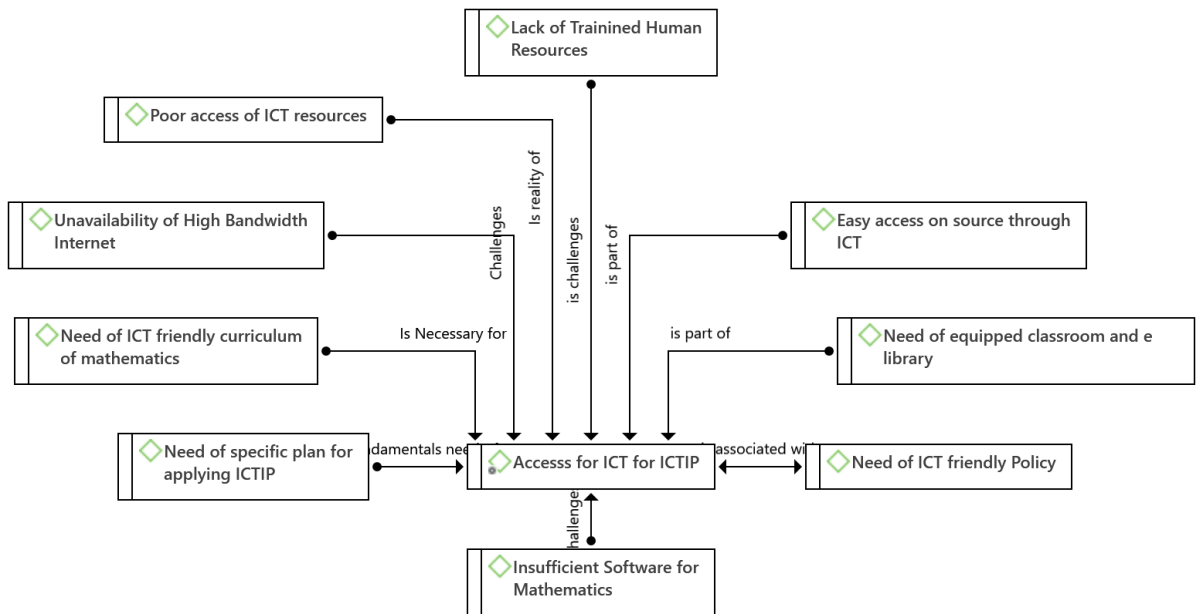
on learning mathematics		
We use different ICT tools and techniques to prepare project work, field work, seminar and assignments.	0.868	0.914
All the assignment and examinations were submitted on Moodle or email through online mode	0.999	0.916
There are several problems to implement ICT integrated pedagogy due to time constraints	1.077	0.913
There are challenges to implement the ICT integrated pedagogy	1.082	0.915
The teaching-learning in your campus are interrupted because of some technological problems	0.985	0.917
ICTIP is not affordable for students due to lack of financial or academic support from institution	1.066	0.924

Appendix M: Reliability Statistics of Output of ICTIP

Statements	Standard Deviation	Cronbach's alpha
The average achievement of students increases after the implementation of ICTIP	0.816	0.915
Application of ICT has made my understanding conceptual	0.796	0.915
I believe that ICT integrated pedagogy contribute on students learning because it makes student active	1.125	0.916
There is a pedagogical shift from conventional teaching approach to ICT integrated pedagogy	0.990	0.916
I believe that ICT integrated pedagogy is useful for teachers' as well as students to visualize abstract mathematical concepts clearly	1.024	0.918
I believe that ICT integrated pedagogy can help students' critical thinking.	1.054	0.919
The ICTIP is useful in higher mathematics classes because it will prevail in the future society	0.995	0.913
The ICT integrated pedagogy is useful for mathematical reasoning and concept development	0.894	0.917
I believe that ICT integrated pedagogy helps us to be critical in thinking	0.941	0.916
I believe that textbooks' preferential role in education will be replaced by new media based on ICT	0.999	0.919
I believe that the teacher's role should be radically changed in future years because of ICT	0.785	0.915
ICT reduces teacher's role which may negatively affect in student's education	1.181	0.917

I believe that the role of educational institutions will be radically changed in future years because of ICT	1.234	0.912
ICT integrated pedagogy produces new models for teaching and learning	0.526	0.917
ICT integrated pedagogy can be a best strategy for teaching and learning every content of mathematics	0.912	0.916
The ICTIP is helpful for applying culturally responsive skills of actively engaging students, using real world examples, assessing your learning other than tests, cooperative learning, and non-authoritarian styles of classroom management	0.774	0.914
For creating equitable learning opportunities in class, massive increase in meaning centered learning opportunity and critical focus on mathematics is needed.	0.780	0.915
Through ICT integrated pedagogy we students from different culture, different socioeconomic status and different level of learning can learn math equally	0.889	0.914
ICT helps us for easy access for learning mathematics in pandemic period of time.	0.795	0.916
The ICTIP create equitable environment in higher mathematics class.	0.722	0.916
ICTIP increases the students' creativity and helps to develop meaning centered activities	0.922	0.916
There is critical focus on every contents of mathematics through ICTIP that makes the teaching learning process natural.	0.780	0.916
ICTIP make the teaching learning process meaningful and contextual.	0.941	0.916
The ICTIP is the best ways for pedagogical transformation.	0.922	0.914

Appendix N: Network between Codes Related to Access of ICTIP



Appendix O: Summary of the Classroom Observation

<i>Observation date</i>	<i>Level/ Mode of class</i>	<i>Topic</i>	<i>Practice of ICT tools</i>	<i>Role of ICTIP</i>
<i>March 19, 2021</i>	<i>B Ed/ Face to face</i>	<i>Hypothesis testing</i>	<i>Power point, SPSS</i>	<i>For conceptual understanding and collaboration, Group work</i>
<i>April 2, 2021</i>	<i>M Ed/ Face to face</i>	<i>Research in Mathematics Education</i>	<i>Videos, Power point, MOODLE platform.</i>	<i>Utilizing flipped pedagogy, engaged learning with discussion, students presentation</i>
<i>March 29, 2021</i>	<i>B Sc</i>	<i>Rolle's Theorem</i>	<i>GeoGebra software, Power point</i>	<i>Engaged and interactive class, equal opportunity for students</i>
<i>April 21, 2021</i>	<i>M Sc</i>	<i>Galois group of polynomial</i>	<i>Power point, White Board, You Tube, link of expert classes</i>	<i>Pedagogical transformation, Practice of Web browsing</i>