USE OF DIGITAL MATHSPAD FOR IMPROVING GEOMETRIC CONSTRUCTION PROFICIENCY IN GRADE X STUDENTS: AN ACTION RESEARCH

Ram Chandra Sitaula

A Dissertation

Submitted to
School of Education

in Partial Fulfillment of the Requirements for the Degree of
Master of Education in Mathematics Education

Kathmandu University
Dhulikhel, Nepal

October 2026

AN ABSTRACT

of the dissertation of *Ram Chandra Sitaula* for the degree *of Master of Education in Mathematics Education,* presented on *8 October 2026,* entitled *"Use of Digital MathsPad for Improving Geometric Construction Proficiency in Grade X students: An Action Research*".

APPROVED BY

……

Asst. Prof. Niroj Dahal, PhD

Dissertation Supervisor

The action research study titled *"Use of Digital MathsPad for Improving Geometric Construction Proficiency in Grade X Students: An Action Research"* is carried out to explore the impact of using one of the digital tool MathsPad to teach geometric construction for class ten students. The experiment was carried out in one of a public school of Jhapa District of Nepal with the participation of 30 students studying class X mathematics as per CDC curriculum. This study was developed from my experience as a mathematics teacher, whereby I noted some difficulties faced by students in comprehending geometric construction concepts using conventional methods of teaching. Difficulties including poor visualization, unconcern, procedural misunderstanding, and minimal participation required the integration of digital technology in geometry instruction. This research project was designed under the interpretive paradigm action research as research methodology. Classroom action was undertaken using thirty Grade X students, out of which six students were strategically chosen as key informants from the perspective of their performance as low, medium, and high performers. Action research involved conducting a process of fifteen days through two action research cycles with processes of planning, acting, observing, and reflecting. MathsPad application was used as part of the intervention to engage students into the learning activity of different geometry constructions such as angle construction, perpendicular bisectors, triangle constructions, and area equivalent constructions.

The findings from the study conducted indicated that there was an improvement in students' engagement, participation, visualization skills, procedure proficiency, and understanding after applying MathsPad. There were more interest and confidence among students while conducting geometrical constructions using the digital approach. It was also revealed that there is a benefit in terms of immediate feedback and visualization while learning collaboratively, thereby leading to less fear and confusion among students while learning geometrical concepts. Finally, this research provided me with an opportunity to reflect on my own practice and learn from it. The study finds that the usage of technological aids such as digital MathsPad can be used effectively to teach geometric constructions at secondary level schools. It is suggested that usage of easy-to-use digital aids in mathematics classrooms can not only promote effective learning but also motivate students. The results found in this study may prove useful for educators of mathematics, curriculum designers, teacher trainers, and educational policy makers who wish to bring about technology integration in mathematics classrooms.

……. 8 October 2026

Ram Chandra Sitaula

Degree Candidate

शोध सार

गणित शिक्षा विषयमा शिक्षाशास्त्रमा स्नातकोत्तर उपाधिको लागि रामचन्द्र सिटौलाको शोधप्रबन्धको शीर्षक "कक्षा १० का विद्यार्थीहरूको ज्यामितीय निर्माण दक्षता सुधार गर्न डिजिटल म्याथ प्याड उपकरणहरूको प्रयोग: एक कार्यमूलक अनुसन्धान" २२ असोज २०८३ मा प्रस्तुत गरिएको थियो।

.....

उप. प्रा. निरोज दाहाल, पीएचडी

शोध निर्देशक

"कक्षा १० का विद्यार्थीहरूको ज्यामितीय निर्माण दक्षता सुधार गर्न डिजिटल म्याथ प्याड उपकरणहरूको प्रयोग: एक कार्यमूलक अनुसन्धान" शीर्षकको यस कार्यमूलक अनुसन्धानको मुख्य उद्देश्य कक्षा १० का विद्यार्थीहरूलाई ज्यामितीय निर्माण सिकाउने क्रममा डिजिटल म्याथ प्याड उपकरणको प्रयोगबाट उनीहरूको ज्यामितीय निर्माणसम्बन्धी दक्षतामा हुने सुधारको अध्ययन गर्नु रहेको छ। यो अध्ययन नेपालका झापा जिल्लास्थित एक सामुदायिक विद्यालयमा पाठ्यक्रम विकास केन्द्रद्वारा निर्धारित पाठ्यक्रमअनुसार अध्ययनरत कक्षा १० का ३० जना विद्यार्थीहरूको सहभागितामा सम्पन्न गरिएको हो।

यस अनुसन्धानको विषयवस्तु अनुसन्धानकर्ताको गणित शिक्षकका रूपमा रहेको व्यक्तिगत शिक्षण अनुभवबाट विकसित भएको हो। परम्परागत शिक्षण विधिबाट ज्यामितीय निर्माणसम्बन्धी अवधारणा र प्रक्रियाहरू सिकाउने क्रममा विद्यार्थीहरूले विभिन्न कठिनाइहरू सामना गरिरहेको अनुसन्धानकर्ताले अनुभव गरेका थिए। विशेषगरी ज्यामितीय आकृतिहरूलाई दृश्यात्मक रूपमा बुझ्न कठिन हुनु, सिकाइप्रति अपेक्षाकृत कम रुचि देखिनु, निर्माणका विभिन्न चरणहरूमा अन्योल हुनु तथा कक्षाकोठाका गतिविधिमा सक्रिय सहभागिता कम हुनुजस्ता समस्याहरू देखिएका थिए। यस्ता समस्याहरूलाई सम्बोधन गर्न ज्यामिति शिक्षणमा डिजिटल प्रविधिको प्रयोग गर्न सकिने सम्भावनातर्फ अनुसन्धान केन्द्रित गरिएको हो। यो अनुसन्धान व्याख्यात्मक अनुसन्धान प्रतिमानअन्तर्गत गुणात्मक कार्यमूलक अनुसन्धान विधिमा आधारित रही सञ्चालन गरिएको हो। अध्ययनमा कक्षा १० का ३० जना विद्यार्थी सहभागी भए पनि उनीहरूको उपलब्धिको स्तरका आधारमा न्यून, मध्यम र उच्च उपलब्धि भएका विद्यार्थीहरूबाट ६ जनालाई मुख्य सहभागीका रूपमा उद्देश्यपूर्ण छनोट गरिएको थियो। अनुसन्धान १५ दिनको अवधिमा सञ्चालन गरिएको थियो। यस क्रममा योजना निर्माण, कार्यान्वयन, अवलोकन र प्रतिबिम्बनका चरणहरू समेटिएका दुईवटा कार्यमूलक अनुसन्धान चक्र अपनाइएका थिए।

अनुसन्धानका क्रममा डिजिटल म्याथ प्याडको प्रयोग गरी विभिन्न ज्यामितीय निर्माणसम्बन्धी गतिविधिहरू सञ्चालन गरिएका थिए। ती गतिविधिहरूमा कोण निर्माण, लम्ब समद्विभाजक निर्माण, त्रिभुज निर्माण तथा समान क्षेत्रफल भएका आकृतिहरूको निर्माणलगायतका कार्यहरू समावेश थिए। डिजिटल

उपकरणको प्रयोगमार्फत विद्यार्थीहरूलाई निर्माणका विभिन्न चरणहरू प्रत्यक्ष रूपमा हेर्ने, अभ्यास गर्ने, आवश्यक सुधार गर्ने र आफ्ना निर्माणहरू पुनः जाँच गर्ने अवसर प्रदान गरिएको थियो।

अध्ययनबाट प्राप्त तथ्य तथा अनुभवहरूले म्याथ प्याडको प्रयोगपछि विद्यार्थीहरूको सहभागिता, सक्रियता, दृश्यात्मक सीप, निर्माणसम्बन्धी प्रक्रियागत दक्षता तथा ज्यामितीय अवधारणाको बुझाइमा सुधार आएको देखाएका छन्। डिजिटल माध्यमबाट ज्यामितीय निर्माणका गतिविधिहरू सञ्चालन गर्दा विद्यार्थीहरूमा सिकाइप्रति रुचि र आत्मविश्वास बढेको तथा सकारात्मक सिकाइ अनुभव विकास भएको पाइयो। त्यस्तै, तत्काल प्रतिपुष्टि, दृश्यात्मक प्रस्तुति र सहकार्यात्मक सिकाइका अवसरले ज्यामितीय निर्माणसम्बन्धी अवधारणाहरू बुझ्न विद्यार्थीहरूले अनुभव गर्ने अन्योल तथा कठिनाइ कम गर्न सहयोग गरेको देखियो। यस अनुसन्धानले अनुसन्धानकर्तालाई आफ्नै शिक्षण अभ्यासलाई नजिकबाट नियाल्ने, अभ्यासका क्रममा देखिएका समस्या पहिचान गर्ने, आवश्यक सुधारका उपायहरू प्रयोग गर्ने तथा ती अभ्यासबाट प्राप्त अनुभवका आधारमा आफ्नो शिक्षण पद्धतिमा परिमार्जन गर्ने अवसरसमेत प्रदान गरेको छ। यस अर्थमा अनुसन्धानले विद्यार्थीको सिकाइमा मात्र नभई शिक्षकको व्यावसायिक सिकाइ र आत्मचिन्तनमा समेत योगदान पुऱ्याएको छ।

अध्ययनका निष्कर्षका आधारमा माध्यमिक तहमा ज्यामितीय निर्माण शिक्षणका क्रममा डिजिटल म्याथ प्याडजस्ता प्रविधिमैत्री उपकरणहरूको प्रयोग उपयोगी र प्रभावकारी हुन सक्ने देखिएको छ। गणित शिक्षणमा प्रयोग गर्न सहज डिजिटल उपकरणहरूको उचित समावेशले विद्यार्थीहरूलाई ज्यामितीय अवधारणा र निर्माण प्रक्रियालाई दृश्यात्मक तथा अन्तर्क्रियात्मक रूपमा बुझ्न सहयोग पुऱ्याउनुका साथै उनीहरूको सिकाइप्रतिको रुचि, आत्मविश्वास र सक्रियता बढाउन योगदान दिन सक्ने देखिन्छ। यस अध्ययनबाट प्राप्त निष्कर्षहरू गणित शिक्षक, पाठ्यक्रम विकासकर्ता, शिक्षक प्रशिक्षक तथा गणित शिक्षणमा सूचना तथा सञ्चार प्रविधिको एकीकरण गर्न चाहने शैक्षिक नीति निर्माता र सम्बन्धित सरोकारवालाका लागि उपयोगी हुन सक्ने अपेक्षा गरिएको छ।

..... २२ असोज २०८३

रामचन्द्र सिटौला

उपाधि उम्मेदवार

This dissertation, entitled *Use of Digital MathsPad for Improving Geometric Construction Proficiency in Grade X Students: An Action Research*, presented by *Ram Chandra Sitaula* on *8 October 2026*.

APPROVED BY

……. 8 October 2026
Asst. Prof. Niroj Dahal, PhD
Dissertation Supervisor

……. 8 October 2026
Dilli Bahadur Raut
External Examiner

……. 8 October 2026
Asst. Prof. Roshani Rajbanshi, PhD
Head of Department, STEAM Education

……. 8 October 2026
Prof. Hem Raj Kafle, PhD
Dean/Chair of Research Committee

I understand and agree that my dissertation will become a part of the permanent collection of the Kathmandu University Library. My signature below authorizes the release of my dissertation to any reader upon request for scholarly purposes.

……. 8 October 2026
Ram Chandra Sitaula
Degree Candidate

© Copyright by Ram Chandra Sitaula
2026
All rights reserved.

DECLARATION

I hereby declare that this dissertation is my original work, and it has not been submitted for candidature for any other degree at any other university.

……. 8 October 2026

Ram Chandra Sitaula

Degree Candidate

DEDICATION

This dissertation is solely dedicated …

To my early childhood Guru, Hari Bhakta Sitaula.

To my parents, Ganga Prasad Sitaula and Ram Maya Sitaula, a source of inspiration and motivation

To my loving better-half, Sunita Thapa Sitaula, and my daughter Adarshana Sitaula and Malvika Sitaula whose ever-consistent guidance and encouragement shaped the direction of my endeavors

&

To all the educators who have taken up the high calling of the teaching profession and are making diligent efforts toward changing and innovating pedagogic practices.

ACKNOWLEDGEMENTS

I am deeply indebted to the many individuals whose encouragement, support, and guidance have been instrumental in the conception and completion of this dissertation. I am immensely grateful to all those who have contributed, directly or indirectly, to making this research journey possible. Their support, encouragement, and guidance have been of utmost importance to me during the process. I am particularly grateful to my dissertation supervisor, Asst. Prof. Niroj Dahal, PhD, because of his support, valuable insights, constructive feedback, and gentle guidance. I am especially grateful for the time, patience, and dedication he invested in shaping this dissertation into its present form. His guidance and encouragement have been a constant source of motivation throughout my research journey. His continuous oversight provided me with guidelines that made me work constantly, kept me active, fast, and dynamic.

Adequately, my interest has never felt apart. The value given by him, years of dialogue with me, played the greatest role in formalizing this dissertation. I also thank my external examiner, and the teacher of teachers, for his kind review and gentle help, which made my work much easier and shorter. My deepest thanks go to Asst. Prof. Roshani Rajbanshi, PhD, for her kind encouragement and invaluable feedback. I am happy to have learned from an excellent group of mathematics lecturers in my MEd course, including Assoc. Prof. Binod Prasad Pant, PhD, Assoc. Dean, Assoc. Prof. Khagendra Adhikari, PhD, Assoc. Prof. Basanta Lamichhane, PhD, Assoc. Prof. Phanindra Bhandari, PhD, Assoc. Prof. Shiva Dawadi, Asst. Prof. Indra Mani Shrestha, Rameshower Aryal, Netra Kumar Manandhar, Sandip Dhungana, Laxman Luitel, Madan Rijal, Manda Pokhrel, Daya Ram Simkhada, Dipika Kutu, Uttam Shrestha and all my dear batch mates. All of them, in their own way, gave me more ideas about teaching and learning mathematics. I express my gratitude to Prof. Bal Chandra Luitel, PhD, former Dean, for his support and guidance during my master's journey.

I would also like to express my gratitude to the Head Teacher, Khadga Prasad Kharel and all teaching and non-teaching members of Mahendra-Ratna Secondary School, Birtamod Jhapa, in the sincerest and most heartfelt way possible for granting me the opportunity to implement my action plan in the school. The students of the

magnificent Grade Ten, Section C, in particular, are very much thanked by me, who welcomed the research process with such enthusiasm. Their trust, curiosity, and involvement were the actual heartbeat of this study.

Finally, I would also like to express my warmest thanks to WCC for editing my thesis language so graciously, and Dr. Noor Jung Shah and Narayan Shrestha, for formatting the entire dissertation in APA style with diligence. I am exceedingly grateful for the support that uplifted me in giving my ideas their final form. Be the blessed anyone! Thank you so much from the bottom of my heart.

Ram Chandra Sitaula
Degree Candidate

TABLE OF CONTENTS

ACKNOWLEDGEMENTS i
TABLE OF CONTENTS iii
ABBREVIATIONS vi
LIST OF FIGURES vii
CHAPTER I 1
INTRODUCTION 1
Background of the Study 1
Personal Experience of Becoming an Educator 2
Conception of Research Agenda 4
Statement of Problem 5
Purpose of the Study 7
Research Questions 7
Significance of the Study 7
Delimitation of the Research Study 8
Chapter Summary 8
CHAPTER II 10
LITERATURE REVIEW 10
Thematic Review 10
Technology Integration in Mathematics Education 11
Geometric Construction in Mathematics Learning 12
Learning with MathsPad Tool 12
Student Learning, Engagement, and Teacher Pedagogical Transformation 13
Theoretical Foundation Behind the Study 14
Vygotsky's Constructivist Theory of Learning 15
Critical Pedagogy: Paulo Freire's Perspective 16
Empirical Review 17
CHAPTER III 20
ROADMAP OF MY RESEARCH 20
Philosophical Assumptions for My Research 21
Ontology 21
Epistemology 21

Axiology 22
Research Paradigm 22
Action Research as Research Approach 23
Research Site and Participants 24
Saanvi 25
Prajwal 26
Samita 26
Prashant 27
Ashiwini 28
Neha 28
Tools and Techniques Used for Data Collection 28
Reflective Journal 29
Photographs and Videos 29
Field Notes 29
Samples of Student Work 29
Semi-Structured Interviews 30
Document Analysis 30
Data Analysis Procedures 30
Ensuring Quality Standards 31
Credibility 31
Transferability 32
Dependability 32
Confirmability 33
Thoughtful Teaching Critical Reflexivity 33
Ethical Considerations 33
Chapter Summary 34
CHAPTER IV 36
INTERVENTION PROCESS AND RESULTS 36
Baseline Data Collection before Intervention: Pre-Test Reflections 36
Teacher-Led Visualization with MathsPad 38
Conceptual Clarity from Digital Visualization 39
Conceptual Understanding of Point, Line & Locus through Digital Visualization 39
Visual Steps of Line Measurement and Bisection 43

Angle Construction and Bisection with MathsPad 49
Increased Engagement and Motivation 56
Active Engagement through Interactive MathsPad Visualization 56
Growing Interest in Digital Learning and ICT Integration 68
Hands-On Digital Practice in the Lab. 73
Development of Digital Literacy 80
Improved Confidence and Self-Efficacy 83
Students' Learning Journey from Struggle to Confidence 84
Growth Through Hands-On Experience 86
Chapter Summary 87
CHAPTER V 89
SUMMARY, FINDINGS, CONCLUSIONS AND IMPLICATION 89
Retrospection as a Researcher 89
Visualization of My Research Plan 91
Research Question Formulation 92
Research Paradigm in the Study 92
Redefining Theoretical Foundations 93
Reflecting Theoretical Referents 94
Constructivist Learning Theory and Concept Ownership 95
Zone of Proximal Development and Scaffolding 96
Cognitive Theory of Multimedia Learning and Visualization 96
Learning Through Visual Representations 96
Reflection as a Teacher-Researcher 97
Challenges in Implementation 98
Conclusions 99
Implications of the Study 99
Limitations 100
Future Directions 101
REFERENCES 102
APPENDICES 108
A 2 -Week Action Plan for Action Research 108
Students Engagement during Action Research Intervention 112
Pre – Test and Post – Test Questionnaire Sample 113
Students' Reflections after the MathsPad Class 114

ABBREVIATIONS

B.Sc.	Bachelor of Science
CDC	Curriculum Development Centre
COVID	Coronavirus Disease
DOTs	Directly Observed Treatment, Short-course
GB	Geometry Box
ICT	Information and Communication Technology
KU	Kathmandu University
M. Ed	Master Degree in Education
MEd	Master of Education
PDF	Portable Document Format
SEE	Secondary Education Examination
TB	Tuberculosis
TPACK	Technological Pedagogical and Content Knowledge
TPD	Teacher Professional Development
UNICEF	United Nations Children's Fund.
USA	United State of America
ZPD	Zone of Proximal Development

LIST OF FIGURES

Figure 1 MathsPad Interface Displaying Points 40
Figure 2 MathsPad Interface Displaying Straight Line and Curved Line 42
Figure 3 Path Made by Marching Ants 43
Figure 4 Visual Representation of Measuring a Line Segment 44
Figure 5 Illustration of Correct and Incorrect Pencil Positioning 45
Figure 6 Demonstration How to Construct a Line Segment 46
Figure 7 Demonstration of How to Construct an Angle of 60° Using Protractor 50
Figure 8 Demonstration of Construction of 60 Degree Using Compass 51
Figure 9 Construction of Angle Using both Protector and Compass 53
Figure 10 Construction of Reflex Angle Using Compass 54
Figure 11 A Complete Construction Question Asked in SEE 57
Figure 12 Construction of Parallelogram Using MathsPad 57
Figure 13 ZPD in Neha's Classroom Scenario 58
Figure 14 Picture Representation of Complete Construction 59
Figure 15 Students' Reflections on the Effectiveness of MathsPad 59
Figure 16 Construction Question for Day 5 61
Figure 17 Step by Step Visualization Using MathsPad 62
Figure 18 Construction of a Quadrilateral and a Triangle with Equal Area 66
Figure 19 Construction of Parallelograms with Equal Area Using MathsPad 70
Figure 20 Teacher's Feedback on Pre-Research Orientation Meeting 73
Figure 21 Conversation between Patient and Doctor 74
Figure 22 Features on MathsPad Tool 77
Figure 23 Participation Name List During Action Research 77
Figure 24 Shapes Drawn by the Participants Using MathsPad Initially 78
Figure 25 Line Bisection and Angle Bisection Using MathsPad 82
Figure 26 A Screenshot of the Task Performance 83
Figure 27 Students Performing Geometric Construction Using MathsPad in Group . 86

CHAPTER I
INTRODUCTION

In this chapter, I present the core of my research study that originated from my own experience as a math teacher while teaching geometric constructions to Grade X students. While teaching geometric construction in the classroom, I discovered that there were many problems among students who failed to understand geometric concepts, visualize geometric constructions, and perform geometric constructions with the help of standard geometry tools. Therefore, this chapter presents the background of the study, my journey as a teacher, the conception of my research agenda, and the statement of the problem that motivated this action research. It also outlines the purpose of the study, research questions, significance of the study, and delimitations of the research. In addition, the chapter highlights the specific difficulties students encountered while learning geometric construction and explains why the integration of digital MathsPad tools was considered a meaningful intervention for improving students' learning experiences in geometry.

Background of the Study

Study of mathematics without conceptual understanding that is 'rote learning is like careless farming'. It was a time when all my friends and I used to practice mathematical problems more and more often to get good marks in the exam. When the exam was over, we tend to forget math as well. It was a practice to pass the exam with good marks, but it was not clear why I was learning mathematics for real-life scenarios. There were no other alternatives other than my teacher. My school life was similar to this kind of environment for learning mathematics, which my teacher was aware of it. Even today, most of the students follow the same path that I did in the past. In the present context, different pedagogies are shifting the mathematics teaching and learning progressively. Piaget (1972) said that *'Knowledge is not a copy of reality. To know an object is to act on it'*. This famous quote supports constructivist learning, where the students construct knowledge through hands-on activities rather than just receiving facts from teachers. Soon, I observed that many of my Grade-X students faced this problem in the concept of geometric construction. After being aware of the potential advantage of digital MathsPad construction tools, I set out to prepare this research plan for my action research in the academic year 2024-2025.

It was not like that at all, however, during my early days of learning. As a child, I was taught mathematics by means of practical activities based on culture, guided by my parents. I was taught mathematics by my father by counting numbers through corn seeds and stone pebbles, as well as constructing shapes like the Bagchal board. Conversely, my mother helped me to understand concepts related to measurement through traditional measuring instruments like mana and pathi to measure grain quantity. Such practices enabled me to grasp the concept of mathematics naturally and sensibly. Nevertheless, once I started going to school, the fixed pattern of learning in schools, as well as the abstract approach in teaching math, especially geometry, hindered my understanding of the subject. In grade seven, for instance, my mathematics teacher taught me how to measure lengths and angles. It was rather challenging for me to comprehend the lessons because sometimes I failed to bring my geometry box to school. There was no money to buy one, so I had to wait until my father brought it from Dharan. By the time I finally got it, I had already been promoted to Grade Eight, so I could not properly learn lines and angles in Grade Seven. My friend and I did not even have bags or copies, so we used to walk to school carrying our books by hand for about one hour from our home. Luckily, United Nations Children's Fund (UNICEF) later started providing polyethylene bags along with one copy each to help us carry and care for our books and copies. My teacher explained everything on the blackboard using chalk and duster and gave us a task to measure the angles of a triangle, but I could not perform it due to my unclear concepts. The teacher did not focus on me and could not manage time to observe whether I was doing my classwork or not. Due to the lack of a geometry box, I was also afraid to ask questions about how to measure properly. As a result, my conceptual understanding could not develop. Gradually, I was promoted to senior classes along with my classmates without having prior knowledge of geometric construction. In the same way, when I was in secondary level, similar methods and techniques were applied in teaching geometric construction. The teacher would show the examples on the board and I would copy it on my note-book and memories the solution by practicing many times. I appeared school level final examination without my conceptual understanding in geometry.

Personal Experience of Becoming an Educator

"You are good in mathematics so you can teach mathematics in our school. Our mathematics teacher is in study leave for two years. If you are interested let me

know". A voice of my head teacher. Since I had a strong knowledge base in mathematics, the head teacher of my school recommended that I could teach mathematics, especially considering that our mathematics teacher had been on study leave for two years. When I showed my interest, he suggested that I should talk in accordance. This story would now be told from the standpoint of my school's head teacher. Once I finished B.Sc. studies, he suggested that I start teaching mathematics at our school. At that point, teaching became a need for me. Therefore, I started teaching mathematics in my school, facing different kinds of challenges such as insufficient content knowledge, pedagogical knowledge, and lack of technology.

Initially, while I used to give lectures on mathematics, students always asked about the hardest subjects. Mathematics was one of them. Even after starting teaching geometric construction to students, many students still faced similar challenges to those I had before. They did not have a geometry box; however, I suggested that they buy a box. I decided to study geometry independently by analyzing many examples available in various textbooks and practicing them repeatedly before I taught the class. However, one of the challenges in the process of studying geometric construction remained the fact that I did not have any instrument to use while giving the lesson. Thereby, I had to give lectures without instruments just by using a chalk and duster.

Thereupon, one-time senior volunteer teacher Mr. Bob Mackforson, from United State of America, watched me teach geometric construction in the class and asked, *"Ram sir, why there isn't any teachers' geometric instrument box in our school to teach the students?"* I responded that, yes, Bob Sir, we really need one. At that time, our school did not have a teacher's geometric instrument box due to limited resources. Mr. Bob Mackforson, who was aware of this issue, decided to arrange the tools for our school. He came back to our school with a teachers' geometric instrument after his visit to Kathmandu. After getting this equipment, I started using it while teaching and this helped my students understand geometry much better. I am very thankful for the help that our valued volunteer teacher provided. Students, however, were coming to the class without the geometry box because of affordability issues or because of the lack of availability of the box in the local market.

From the existing literature, we know that integrating text and pictorial representations during the reading activity enables knowledge structure formation (Schnotz et al., 2014). While being very useful, the concept did not fit my situation.

Therefore, while trying to use more than conventional examples, I looked for any YouTube video on geometric constructions where the MathsPad is used as an additional instrument in the process of construction. Based on the findings, I started including this idea of applying MathsPad while teaching geometric constructions. Now I use MathsPad online construction tool in order to teach geometric constructions to the students at the secondary level. Students become very enthusiastic in learning geometric constructions along with using laptop computers, MathsPad, projectors, and other digital means. From time to time, I also use an interactive panel board for teaching.

While my experience as a mathematics educator continued, I started a two-year program called Masters in Education in Mathematics Education at Kathmandu University. During this program, I became familiar with different methods of teaching mathematics and classroom technologies. During the first semester, I took the course Information and Communication Technology (ICT) under the guidance of course facilitator, Niroj Dahal. He acquainted us with different software and their usage in mathematics. Thus, it motivated me to include these in my teaching. Moreover, he introduced me to ICT. As a result, ICT helped me in managing students better during teaching geometrical constructions and other topics in mathematics. Moreover, I started using MathsPad to create visual and interactive manipulative for teaching geometric constructions.

Conception of Research Agenda

On the basis of the general academic concept, I know that geometric construction is a part of mathematics in school education that is important in developing skills to be accurate, logical, visual, and spatial. It asks students to create geometric figures with a ruler, compass and protractor by following systematic and precise steps. In this modern era, technology has become extremely significant in many areas such as education. Teaching and learning approaches are also evolving to facilitate students' understanding of mathematics in the context of the development of digital tools. While in many public schools in Nepal, there are still challenges if using technology to make the classroom teaching effective.

My previous experience in Japan was also helpful to gain insight into the role of mathematics in the real world. In those days my job was to create the inner circular part of a car in a company. I attempted to do the job but there was a minor error with the diameter measurement. This oversight caused the product not to meet the standard

and so I lost the job. From this experience I was able to realize that any relatively small error in measurement or geometric construction can lead to large problems in quality, safety and professional work. It allowed me to see the importance of accuracy and proper understanding of geometry in everyday life. I realized that students in Nepal have so much trouble with geometric constructions in grade 10. On reviewing student test papers in 2024, I found that students were not able to solve even simple construction problems. Very few of them answered the questions but most of them didn't attempt. This revealed that students did not have a sound knowledge of the fundamental concepts. Students told me that they were not interested in geometry. Even among good students, some said they were not well-versed in topics of construction in the beginning. From this I realized that it was not merely the effort of the students, but also the classroom methodology that was the issue.

I felt this made me think about my own teaching practice. I found that it was not sufficient to only use traditional teaching methods to help students to understand the geometric construction clearly. So, I began to think about new approaches for teaching geometric construction topic, using digital MathsPad devices. Based on this, I decided to do the action research study to enhance students' skills in geometric construction with the use of MathsPad tool. I feel that technology can be beneficial in the classroom for students to understand, see pictures of what they are learning, and help them to be more interested in learning mathematics. By improving students' geometric construction proficiency, this study aims to contribute not only to their academic achievement but also to the development of practical skills that may support their future educational and professional success in their real life.

Statement of Problem

Currently, in Nepal, the topic of geometric construction in public schools is still learned using the conventional approach to instruction. Typically, geometry lessons integrate board work with textbooks, and students widely use conventional instruments, including a ruler, compass, and protractor. While the concept of learning by doing is the focus of the curriculum, teacher-centered classroom instruction fails to incorporate any technology-related aspects. As a result, many students encounter difficulties in understanding the procedure of geometric construction. As a secondary mathematics teacher, I noticed that most grade X students struggled with geometric construction after several examples were given to them. Many learners seemed to remember geometric constructions through repetition but failed to understand the

logic behind this process. Additionally, even though verbal explanations were offered, many students remained puzzled, unable to understand what was done in the drawings. In particular, there was no way for students located at the back of the classroom to see the demonstrative materials. Moreover, several students lacked necessary instruments, which contributed to the loss of motivation for geometry studies. The observation also showed that many students felt uncomfortable about performing geometric constructions because they did not receive adequate guidance or interactions. Conversations with SEE test-takers proved that students perceived geometry problems as difficult, and some even failed to complete them because of omitting questions. Reviewing SEE mathematics answer papers made me conclude that many students do not master the concepts of geometric construction. For instance, existing literature reveals how numerous students put much emphasis on memorization and neglect other aspects of geometric construction (Aphrodite & Rita, 2021; Sam-Kayode, 2025). At the same time, Chavula and Nkhata (2019) claim that the use of teacher-centered strategies leads to poor geometry skills.

During my instructional practice, I realized that the lack of appropriate opportunities leads to the difficulties associated with visualizing, exploring, interacting with material, and getting instant feedback from teachers. The problems mentioned above foster a negative image of geometry as an abstract and complicated subject, which motivates me to try to apply the digital MathsPad tool to teach students how to construct geometric figures. The implementation of visual tools increases the level of engagement and interest in the discussed area. Personal experiences with mathematics are another example of how traditional learning techniques can be ineffective. For example, once I faced a similar challenge helping my daughter with a geometry lesson. However, digital technologies, particularly the MathsPad application, are key to enhancing geometrical education since they enable one to visualize geometric forms and make geometrical education participatory and conceptual. Nevertheless, Nepal is faced with the challenge of providing sufficient ICT resources, infrastructure, and professional development for teachers, especially in rural and underprivileged schools (Rana et al., 2021). Therefore, I am interested in researching. This is why, according to my teaching experience, many students in Grade X have experienced difficulties in learning geometrical constructions because of their lack of understanding of geometrical concepts, poor skills of geometrical construction, and engagement with the learning activity. This was mostly because of

traditional methods of learning that lacked effective participation tools. That is why this study was conducted to explore the usefulness of integrating MathsPads technology into teaching geometrical constructions.

Purpose of the Study

The main purpose of this action research was to explore how the use of the MathsPad application supported Grade X students' learning of geometric constructions, particularly their conceptual understanding, motivation, confidence, and interest in geometry. The study also examined the teacher's perspective by reflecting on my own teaching practices, experiences, assumptions, and beliefs about integrating technology into mathematics teaching. Through this process, I aimed to understand both the students' learning experiences and my own professional growth in using MathsPad to make geometric constructions more meaningful and accessible.

Research Questions

This research explores the use of MathsPad construction tools and aims to answer the following research questions:

- How does the application of digital MathsPad tools affect the geometric construction skill of Grade X students?
- What role do digital MathsPad tools play in developing students' conceptual understanding and interest in geometric construction?
- How did the use of the MathsPad application influence my professional development and improve my teaching practices in teaching geometric constructions to Grade X students?

Significance of the Study

The significance of this study lies in its potential to improve students' learning experiences and my own professional practice through the integration of the MathsPad application into the teaching of geometric constructions. For students, the study aims to support a deeper conceptual understanding of geometric constructions while improving their practical construction skills, motivation, confidence, and interest in learning geometry. For me as a teacher-researcher, the study provides an opportunity to reflect on my teaching practices, identify instructional challenges, and develop more effective ways of integrating digital technology into mathematics lessons. The findings may also offer useful insights for other mathematics teachers who wish to use ICT tools to make geometry teaching more interactive, meaningful,

and student-centered. Furthermore, the study may inform schools, curriculum developers, and educational policymakers about the opportunities and challenges of incorporating digital tools into mathematics education. Beyond improving students' examination performance, this study emphasizes the importance of developing students' confidence and ability to apply geometric knowledge in practical situations. Overall, the study seeks to contribute to both students' conceptual learning and my continuing professional development as a mathematics teacher.

Delimitation of the Research Study

This study was limited to one public secondary school in Jhapa District, Nepal, where I conducted action research with a single section of 30 Grade 10 students. As a teacher-researcher, I focused specifically on the Construction chapter of the Grade 10 Mathematics curriculum developed by the Curriculum Development Centre (CDC), Nepal. The study examined how the use of the MathsPad application supported students' learning of geometric constructions and how this experience influenced my own teaching practices. I used MathsPad as the only digital tool in the study; other digital applications, mathematics topics, and grade levels were not included. The action research was conducted over a period of 15 days. Therefore, the findings reflect the learning experiences of the students and my professional reflections within this particular classroom context and period. They may not represent the experiences of students in other schools or educational settings.

Chapter Summary

Chapter I introduces the background of my study and explains the experiences and concerns that motivated me to conduct this action research. As a mathematics teacher, I observed that many Grade 10 students experienced difficulties in understanding and performing geometric constructions through conventional teaching methods. These classroom experiences encouraged me to explore how the MathsPad application could support students in learning geometric constructions more meaningfully. This chapter presents the research problem, the purpose of the study, and the research questions focusing on students' learning experiences and my own professional development as a teacher-researcher. It also explains the significance of the study for students, mathematics teachers, schools, and other stakeholders interested in integrating digital technology into mathematics education. Finally, the chapter outlines the delimitations of the study, including the school context, the participating students, the selected mathematics topic, the use of the MathsPad

application, and the 15-day period of action research. Overall, this chapter establishes the foundation for understanding why I undertook the study, what I intended to explore, and how the research was focused.

CHAPTER II
LITERATURE REVIEW

In this chapter, I have reviewed the relevant literature that provides a conceptual, theoretical, and empirical foundation for my study. This includes brief reviews of literature regarding the problems faced by teachers and students during the teaching and learning of Construction using MathsPad. Through this literature review, a conceptual framework was developed to contextualize the present study in light of current scholarship. The first section explores the general aspects of the teaching and learning of geometric constructions in secondary school mathematics curricula based on the curriculum developed by CDC, Nepal. The second section delves into the issues pertaining to technology integration in mathematics education with a view to examining how the use of ICT can be employed to overcome some difficulties encountered by secondary-level students in constructing geometrical figures. Thirdly, constructivist perspectives on learning and instruction in the field of mathematics will be explored. Lastly, past works in digital technology-based geometric constructions were reviewed. These include studies that employed MathsPad, a dynamic geometry software application, for the teaching and learning of geometric constructions. This chapter serves as a means to develop a theoretical framework which can be used by both researchers and educators to understand how the use of technology can enhance learning processes, thus giving rationale for classroom practitioners to apply their knowledge in practice in a meaningful way. To have a clearer understanding of theory in practice, a report of the 15-day intervention to investigate the impact of utilizing technology will be presented in the following chapter.

Thematic Review

This part outlines the key themes that served as the framework for the current research titled, "Use of Digital MathsPad Tools for Improving Geometric Construction Proficiency in Grade X Students: An Action Research" The purpose of the thematic review is to establish the theoretical foundation of how digital MathsPad technologies can facilitate improvement in students' geometric construction skills as well as highlight the factors that can contribute to the successful implementation of the 15-day intervention in this study.

Technology Integration in Mathematics Education

Technology has made a great impact on teaching and learning in the classrooms all over the globe. It provides various ways for the students to engage in the learning activities and also helps teachers to create more interactive classroom environments. In mathematics education, technology is particularly useful in illustrating, investigating and solving mathematical problems as it makes abstract concepts more visible and easier for students to study. According to Zulnaidi et al. (2020) using technology can create a meaningful experience in the classroom by involving the students in an active role while developing their understanding of mathematics.

Digital technology plays a special role in the study of geometry since learning geometry involves students having to visualize figures, construct geometric objects and understand the relationships between them. In dynamic digital environments students are able to create and alter points, lines, angles and geometric shapes while seeing how a change in one part of a figure influences the other parts. These kinds of activities can assist students in exploring geometric relationships and in forming their own conjectures (Danesi, 2016). Likewise, Günster and Weigand (2020) stressed the importance of interactive learning environments in enabling students to work with mathematical ideas by means of purposeful tasks rather than relying solely on static diagrams. By means of such activity's students can link what they see on the screen with the relevant mathematical concepts and thus may come to have a deeper understanding of geometry.

The presence of digital resources in a classroom does not ensure effective technology-based learning; the use of technology is heavily reliant on the teachers' knowledge, skills, confidence and pedagogical choices, as well as on the teaching and learning conditions within the school. Research on technology integration suggests that teachers' technological and pedagogical knowledge and their willingness to use digital resources appropriately in the classroom are important (Knezek & Christensen, 2016). In Nepal too, the introduction of digital technology into schools is hindered by a number of practical difficulties, including insufficient ICT infrastructure, unequal access to digital resources, an unreliable electricity supply, poor internet connectivity, and a lack of opportunities for professional development (Ministry of Education, Science and Technology [MoEST], 2022; Rana et al., 2021).

The educational value of a digital mathematics tool such as MathsPad cannot be judged merely by the fact that the technology is available. Rather, it relies on the way in which the teacher integrates it into classroom activities, on how the students are guided in its use, and on whether the school provides an environment conducive to teaching and learning based on technology. So, to understand how digital technology can be used to enhance students' learning of geometrical concepts as well as their ability to carry out constructions, we need to look at the use of MathsPad in real classroom practice.

Geometric Construction in Mathematics Learning

Geometric construction is one of the important elements of the mathematics curriculum that provides a strong basis for further study of engineering, architecture, design, and other disciplines. Geometric constructions involve the creation of figures such as lines, angles, triangles, circles, and polygons in accordance with mathematical principles. Geometric constructions foster the development of students' logical skills, spatial visualization, accuracy, and problem-solving capabilities (Hoyles & Noss, 2008; Sullivan & Heffernan, 2016). Construction with geometric instruments is one of the widely used approaches to geometric constructions. However, although geometric construction is extremely important for mathematics education, it may be quite complicated since not all students are able to construct figures precisely and learn mathematical concepts underlying geometric constructions. To achieve positive results, students need to know why particular actions should be performed.

Another important aspect that should be considered in the process of introducing geometric construction in mathematics is the potential use of digital technologies. Software such as MathsPad can help learners to work with geometric objects and explore geometrical constructions. Using this program, the student will be able to determine quickly if his construction is correct and make changes accordingly. Dahal et al. (2022) found that learning geometry with the help of GeoGebra provided students with opportunities for dynamic visualization and exploration of geometric transformations, promoting discovery learning, cooperation, and understanding of abstract geometric concepts.

Learning with MathsPad Tool

MathsPad is an education software which encourages learning in mathematics with visual and interactive tools. With this technology students can draw and manipulate geometric objects, explore mathematical relationships and explore

geometric ideas dynamically. MathsPad offers opportunities for learners to experience objects, to get immediate feedback, and to have a better understanding of mathematical ideas (Hoyles & Noss, 2008; Thurm & Barzel, 2024; Zhang et al., 2023). Students can present their work freely in constructions and can start working when it is problematic and continue to work on it until they master it. Furthermore, through MathsPad, students can manipulate and transform geometric objects and figures by moving, rotating, enlarging, and decreasing them to deepen their understanding of geometric transformations and relationships. Danesi (2016) said these features enable students to comprehend the mathematical concepts more deeply and to engage in learning.

Finally, this technology promotes the transfer of geometrical construction skills from the classroom to everyday life. Students can be shown the use of geometrical figures through activities like designing houses, gardening, designing logos, designing patterns for buildings etc., which helps them appreciate and understand the concepts of mathematics and the importance of geometry in life. These attributes of MathsPad are suitable tools for introducing the constructivism approach in teaching mathematics in the classroom.

Student Learning, Engagement, and Teacher Pedagogical Transformation

The existing research shows that technology-supported learning environments play an important role in enhancing the motivation, engagement, and academic achievements of students. Geometrical concepts may present challenges to students who need to visualize shapes and understand spatial relations. In this regard, technology tools like MathsPad help address these challenges and allow students to overcome them. Firstly, the instantaneous feedback that MathsPad provides enables students to identify and fix their mistakes instantly. Through MathsPad, there is the possibility of accommodating all types of learners since it provides visual and hands-on experience with geometry construction. This might help the students gain confidence in themselves and actively engage in problem-solving activities involving geometry. Thus, in my experience, technology-enhanced learning will result in a better understanding of mathematical concepts and improved geometrical skills. In addition, the use of technology changes teachers' roles significantly. Teachers no longer act as intermediaries, but as facilitators to assist learners in exploring and to facilitate in collaborative processes. Teachers are expected to create stimulating learning tasks, offer students appropriate scaffolding and encourage students to learn

mathematics on their own. Technology supported mathematics learning environments can provide opportunities to actively involve students in mathematical tasks, explore ideas, and interact with peers, leading to mathematical understanding (Günster & Weigand, 2020). Collaborative activities can also help students organize their thinking and co-construct mathematical knowledge in a dynamic geometry environment (Doerr et al., 2021). However, for effective technology integration to occur, teachers must cultivate technological and pedagogical knowledge and skills to evaluate, select, and implement technology-aided learning activities and to support learning with technology (Knezek & Christensen, 2016). Teachers need to gain the appropriate skills to make effective use of MathsPad and support learning and communication. Hence, professional development and continuous learning are essential to update their knowledge and skills. Action research encouraged teachers to implement technology, analyze outcomes, and plan subsequent steps. The current research follows this pattern to assess the effectiveness of MathsPad on the geometrical construction of Grade X students.

Theoretical Foundation Behind the Study

MathsPad is a geometry program that operates digitally, either on computers, tablets, or any digital device, and is designed to assist in constructing geometrical figures and shapes. Some of the construction tools available include points, lines, line segments, circles, arcs, angle construction, angle bisection, line bisection, a measuring tool, and a dynamic dragging facility. The visualization process will enable students to have a better grasp of geometric relationships, manipulation of figures, and verification of constructions, with the added benefit of receiving visual feedback instantly. Visualization makes it possible for students to have deeper insights into geometric ideas beyond what is possible through drawing simple static figures on the board. The choice of MathsPad for this action research is based on its simplicity and user-friendly interface compared to complicated software like GeoGebra and Desmos, which have too many features that would confuse students who are beginners in using such software. In addition to its simplicity, MathsPad enabled Grade X students to focus on how to perform the construction, understand the geometric relationships, and learn about the problem-solving process, instead of wasting their time trying to master difficult technicalities. To carry out and interpret the results of the MathsPad-based action research intervention, the following theoretical lenses were used.

Vygotsky's Constructivist Theory of Learning

Constructivist learning theory regards knowledge as something that learners build or construct themselves based on their experiences, pre-knowledge and newly learned knowledge. Learning is not a passive process, but an active one in which learners construct and deepen their knowledge by engaging actively with learning experiences. Social constructivism takes this a step further, highlighting that knowledge is also socially constructed by means of social interaction, dialogue, collaboration and culturally mediated learning experiences (Saleem et al., 2021). From the social constructivist perspective, learners typically learn optimally when they pursue their own goals. In this case, social constructivism can be used in developing educational settings in which learners participate in learning-related activities, explore new things through experience, and collaborate to gain a full understanding of concepts. In mathematics learning, particularly in geometric construction, the use of digital tools such as MathsPad can support social-constructivist learning by providing opportunities for students to explore geometric relationships, discuss their observations, collaborate with peers, and construct mathematical understanding with appropriate teacher guidance (Olive et al., 2010). In this regard, social constructivism suggests viewing students as active knowledge creators but not just as receivers of knowledge. The roles of educators in such a class become those of facilitators rather than those of centralized figures. Humans are social creatures who must adapt themselves to a changing society. According to Vygotsky (1978), social interaction plays a crucial part in the cognitive development of children. Therefore, the theory of social constructivism corresponds to the problem of the study, as the latter is related to the issue of geometric construction in terms of the use of the MathsPad digital tool. To meet modern requirements of education in the era of digitalization, scaffolding becomes significant as learners' knowledge is being actively constructed. From the constructivist point of view, adults, or so-called more knowledgeable others, act as the main sources of knowledge among learners. This understanding of teaching provides scaffolding that learners receive in the ZPD.

The current study aimed to examine how MathsPad can be used as scaffolding to facilitate learners' geometric construction. An element of the theory is the concept of Zone of Proximal Development (ZPD). It is defined as the difference where learners can work independently versus with help. From this idea, Anghileri (2006) made the assertion that successful mathematical instruction happens when scaffolding

is provided by the teacher and slowly is removed as the students become knowledgeable and more independent. Scaffolding, Margolis (2020) says, is the teacher's dimension of everyday teaching that when combined with cooperation, prompts students to advance above their current levels of understanding. Recently, Li et al. (2024) demonstrated that with the combination of visual resources to teacher scaffolding, and cooperation, remarkable progress in the mathematical understanding and thinking of learners is shown. All the above-mentioned theoretical perspectives influenced my action research significantly; thus, I used MathsPad as a scaffold for Grade X learners in order to encourage them to learn to construct geometric figures using dynamic visualization, teacher-guided work, instant feedback, and classroom collaboration. Gradually, as learners became more experienced in constructing the geometric figures, my assistance decreased.

Critical Pedagogy: Paulo Freire's Perspective

Critical pedagogy, as developed by Paulo Freire (1970), provides an additional theoretical perspective for understanding teaching and learning in this action research. Freire criticized the traditional "banking" model of education, in which teachers are treated as the primary source of knowledge and students are expected to receive and memories information passively. Instead, he emphasized dialogical, problem-posing education that encourages learners to question, reflect, participate, and develop critical awareness of their experiences. In the context of teaching geometric constructions using the MathsPad application, this perspective encouraged me to move beyond simply demonstrating construction procedures and asking students to follow them. Rather, I aimed to involve students in exploring geometric relationships, asking questions, explaining their reasoning, discussing ideas with their peers, and reflecting on their learning. It also encouraged me, as a teacher-researcher, to examine my own assumptions and classroom practices and to recognize students as active participants in the learning process. Freire's concept of praxis, which connects critical reflection with action, is particularly relevant to action research because it highlights the importance of reflecting on teaching experiences and using those reflections to improve classroom practice (Freire, 1970). Thus, critical pedagogy complements the study by emphasizing student participation, dialogue, critical reflection, and the continuous improvement of teaching and learning.

Empirical Review

The review of empirical literature is quite significant for me, since it has helped me to find out which issues have already been discussed and which require further research. There are a lot of studies dedicated to the usage of computer-based programs to help students learn geometry and other branches of math better. Most of them have examined the application of popular software like GeoGebra and Desmos, but there is only little information on using MathsPad to teach geometric construction to secondary school students. It became my motivation for doing this research. From the review of literature, it is evident that the use of digital technologies in the existing body of research positively affects the way learners comprehend geometry using visualization and interaction. I learned that according to the results found by Thurm and Barzel (2024) that digital technologies can be used to learn interactively with visualization in math. Similarly, according to Zhang et al. (2023) and Awaji et al. (2025), dynamic geometry software should be used to develop the understanding of notions such as congruence, symmetry, transformation and relations. Further, Gurmua et al. (2024) and Koirala and Bhatta (2023) investigated the effect of ICT on geometry performance and engagement. In addition, the application of technology, as concluded by Acharya (2025), can develop the ability to visualize and have spatial senses in the learning process.

In addition, based on my study of the literature, it can be seen that utilizing digital tools in learning activities also results in positive impacts concerning students' performance. According to Walter (2024), the use of digital technologies in teaching mathematics enables learners to understand the concepts of mathematics through visualization, experiments, and experiential learning. According to Kumar et al. (2023) and Singh and Sharma (2024), the interactive geometry software has a positive impact on learning. Further, Shrestha (2025) reported that the use of ICT learning resource enhanced the students' interest and minimized the errors which occurred due to the provision of timely feedback. Motivation and engagement of students have been investigated in great deal in the literature too. Ramzan et al. (2023) found that in the context of the interactive involvement of technology, learners are more motivated and cooperative in math classes. The learning experience of being involved with ICT also included active participation in the learning process of students as noted by Ali et al. (2024) and Bhandari and Koirala (2025). ICT based learning not only removes fear

from mathematics but also enhances the learners' confidence, as Sharma (2024) asserts.

Studies conducted empirically have also indicated the positive impact of digital technology on the development of the cognitive abilities of students. Hoyles and Noss (2008) suggested that dynamic geometry environments play an important role in fostering conceptual growth among students since they help learners explore and manipulate the various geometric relationships. The most recent studies by Zhang et al. (2023) and Li and Wang (2024) suggest that under similar environmental conditions, logical and problem-solving skills and a spatial geometry orientation are developed. The findings made by Shrestha and Adhikari (2025) indicate that the use of digital technology supports the ability of students to think reflectively about the relationships between geometric shapes. A third highly important finding in this study of literature indicated that there is an extremely crucial role for teachers in the process of integrating technology. Drijvers and Sinclair (2024) argued that technology will not be a lever for change unless it is accompanied by appropriate teaching and facilitation. Even though there are several references in the existing literature about the effectiveness of digital technologies in teaching geometry, all the references found were about GeoGebra, Desmos, and other frequently explored technological tools. I hardly found literature on MathsPad and its use in geometric construction, more specifically for Grade X students. There is an identified gap in this regard, which needs to be filled using this action research, as it will help explore students' experiences, engagement, knowledge construction, and confidence while learning geometric construction using the simple technological tool called MathsPad.

Research Gap

Studies in recent years have confirmed that the use of digital tools, including GeoGebra, has helped improve the understanding, spatial abilities, visualization skills, and geometrical achievements of the students (Awaji et al., 2025; Gurmua et al., 2024; Thurm & Barzel, 2024; Zhang et al., 2023). Likewise, some studies have also found that technological environments improve the engagement, confidence, and motivation of students when learning mathematics (Ali et al., 2024; Ramzan et al., 2023; Sharma, 2024). In addition to this, some researchers have stressed that there is an important role of teachers in the integration of technology (Drijvers & Sinclair, 2024; Sharma et al., 2025). Nevertheless, despite their invaluable contributions to knowledge, the current literature seems to be dominated by studies on GeoGebra, Desmos, and other

dynamic mathematics software. There is very scarce empirical evidence on the application of MathsPad as a digital tool for geometric constructions in teaching at the secondary school level. Also, a very limited number of studies exist that focus on the ways a relatively easy-to-use digital tool can help students understand conceptually, engage in, and build up confidence while learning geometric constructions. This aspect is particularly important because many schools in Nepal continue to face challenges related to ICT infrastructure, teachers' ICT training, and the integration of technology into classroom instruction. Evidence indicates that opportunities for ICT-related teacher training remain limited, while traditional approaches to teaching continue to be prevalent in many schools (Rana et al., 2021). Thus, classroom-based action research is needed that would investigate the use of digital tools like MathsPad in teaching practices. For this reason, the present study has been conducted to examine how the use of MathsPad helped students of Grade X learn geometric constructions and how it benefited my teaching practice as well.

Chapter Summary

This chapter analyzed literature that is pertinent to my action research on the use of digital MathsPad tool for the development of geometric construction skill among Grade X students. It started by examining the significance of geometric construction in mathematics teaching and the increasing trend of using digital technology in order to promote students' conceptual knowledge, visualization skills, and problem-solving abilities. Following this, it discussed the theoretical underpinning of the study based on the Social Constructivist Theory of Lev Vygotsky and the theory of Zone of Proximal Development (ZPD) and scaffolding. It is pertinent to state that the chapter also reviewed the empirical literature regarding the role of digital technology integration in geometry education in terms of its effect on the students' conceptual understanding, engagement, cognitive growth, and teachers' mediation in technology-based learning. The literature review made it evident that the majority of the existing research is concerned with the software like GeoGebra and Desmos; however, there is hardly any research conducted regarding the use of MathsPad software in education, especially in relation to the teaching of geometric construction in secondary schools. The research gap found on the basis of this literature served as the reason for this action research.

CHAPTER III
ROADMAP OF MY RESEARCH

In this chapter, the overall design of the research, together with the methodological framework employed in this action research to enhance the skills of geometric construction among Grade X students using digital MathsPad software, was discussed. The chapter starts by discussing the philosophical assumptions used for conducting the research, where the major one is the constructivist assumption on the creation of knowledge through learners' experiences, interactions, and reflections. As per the philosophy, I carried out the research using the interpretivist research paradigm, where I was able to examine students' experiences and my own practice by including MathsPad in geometric construction teaching. The chapter continues with an overview of the general methodology used in this research. Reasons behind choosing the action research method are provided to explain why this is the best method that can be used to analyze and improve my classroom practice. The chapter goes on to provide details about the research design, the research site and participants, the sampling technique, the intervention process, and the two action research cycles conducted within fifteen days. The chapter provides information on the methods used for data collection, the data analysis and interpretation process, trustworthiness of the study, and ethical considerations. This research is based on the qualitative action research approach, where I, the researcher, conducted an in-depth planning, implementation, observation, and reflection of my classroom teaching-learning experience within the natural classroom context. Therefore, this chapter aims to discuss and detail the process of conducting the research during the period of 15 days while conducting the "Construction" module based on the curriculum of Grade X. This chapter is divided into different sub-sections. First, the research design of this study was presented along with an explanation of why action research is best in solving problems arising from mathematics classroom experiences. Second, a description of the research context which included a discussion of the chosen community school, Grade X students, and the classroom context. Third, there was a detail on the participants of the research as well as on how the students learned the geometric construction with the help of the MathsPad. Moreover, the use of MathsPad for the development of stepwise instruction was explained as an integral part of the

intervention process. Lastly, there was a discussion regarding the data analysis strategy, including both qualitative data interpretation and quantitative comparisons. Overall, this chapter gives insight into how the research was actually carried out. This looks at how the researcher acted as a facilitator and how he or she used reflection and feedback to adapt his or her teaching practices, while using MathsPad technologies to construct geometry.

Philosophical Assumptions for My Research

This research on the use of digital MathsPad to enhance the construction skills of Grade X students was guided by three philosophical assumptions; ontology, epistemology, and axiology, which shaped my understanding of reality in the research context, the construction of knowledge, and the significance of this study.

Ontology

For me, as both researcher and educator, classroom experience is neither singular nor constant. It is multiple, and it results from the varied experiences that students undergo as they learn. Geometric construction can provide students with varied learning experiences, ranging from relatively straightforward to more challenging tasks, depending on their interaction with digital tools such as MathsPad (Olive et al., 2010). I believe that learning mathematics is not about getting the right answers. It requires student experience, building, and skill development in the classroom.

Epistemology

Based on my findings, learners gain knowledge through interacting with the facilitator and using the MathsPad program. According to the constructivist approach, it is difficult for students to grasp the concept of geometry by observing or listening to passive teaching, students need to have opportunities to actively experience the learning of geometry, explore the relationship between geometry problems, construct the representation of geometry, and reflect on the construction process. (Anthony, 1996; Vitale et al., 2014). In order to learn geometry effectively, there should be some construction involved, during which learners have to imagine figures, make experiments, correct their mistakes, and receive timely feedback from the software program. The process of learning involves such activities as dragging, construction, transformation, and reflection on the geometrical figures using MathsPad.

Axiology

This inquiry has a significant value base in relation to me being both the instructor and the researcher. The way I design my lessons, use MathsPad software, and evaluate my learners' responses is influenced by my personal values, beliefs, and instructional objectives (Speer, 2005; Stipek et al., 2001). Recognizing this influence is important because teachers' beliefs about mathematics teaching and learning can shape their instructional decisions and classroom practices. In particular, I am convinced that any study process should have students at its heart and provide an equal opportunity for all students to participate in the investigation of geometric shapes. Therefore, while evaluating the extent to which my students improve, I seek to increase their engagement during the process. Thus, while studying how my students acquired knowledge about geometric constructions through MathsPad, I was also trying to improve their involvement, participation, and learning process in the classroom environment since, according to Vygotsky (1978), knowledge is actively constructed through interaction and reflection.

Research Paradigm

The paradigm that underpins my research is interpretivism, and it is suitable for studying the manner in which Grade ten students develop meanings while learning geometric construction using a digital MathsPad. A research paradigm can be defined as a group of views, assumptions, and approaches employed in a study to design the research and interpret its findings. Interpretivism was chosen in my study because it deals with actual situations in class, the learning process, and the learners' perception of geometry through technology. In the interpretivist paradigm, the process of knowledge acquisition is considered socially constructed. This means that knowledge is generated by interactions between the teacher, learners, and teaching materials in a particular setting. In my study, such interaction occurred during mathematics classes involving the use of MathsPad for constructing, viewing, and manipulating geometric shapes. In addition, contemporary works in Mathematics Education stress that learning geometry should be made more purposeful by having the learners interact with digital platforms that facilitate exploration, reflection, and conversation rather than rote memorization (Drijvers & Sinclair, 2024; Thurm & Barzel, 2024). Interpretivism provided me with an opportunity to analyze in great detail the way students reacted to the activities using MathsPad technology, how they gradually grasped the construction process, and became more confident and motivated while

completing the assignment. In this regard, the interpretivist approach does not view the process of acquiring knowledge as an established product but rather as an activity whose meaning is created in interaction. Moreover, I was able to reflect on my teaching practices as I was facilitating students to perform the tasks on constructing figures using the MathsPad technology.

Action Research as Research Approach

The reason for selecting action research as the primary research methodology was its relevance to my role as a teacher-researcher and its potential to support the improvement of my professional practice while simultaneously investigating students' learning (Mertler, 2020). Action research enables teachers to systematically examine their own classroom practices, reflect on evidence generated through the inquiry, and make informed changes to improve teaching and learning (Kemmis, 2009; Mertler, 2020). Given that this study aimed to improve Grade X students' skills in constructing geometrical figures through the use of MathsPad, action research was considered appropriate because it is practical, context-sensitive, and directly connected to classroom practice and improvement (Mertler, 2020; Sagor, 2000). For my research, two cycles of action research were done. In the first cycle, I identified the major problems experienced by the learners in their construction activity, including inaccuracy, problems with the process itself, and poor involvement. Then, from the results of the identification process, I created lesson plans incorporating the MathsPad game based on the topic of "Construction" in class ten. In each of the lessons, there were lesson plans including the objectives, digital constructions of geometry, demonstration by the teacher, learner's activity with the MathsPad, and some reflective exercises.

Following reflection on the first cycle, I identified several areas that required improvement, including providing clearer instructions, demonstrating geometric construction procedures more carefully, and allowing students more time to practice using the MathsPad application. During the first cycle, I taught the basic concepts and procedures of geometric constructions in the Grade 10 Mathematics curriculum, beginning with foundational concepts where necessary and gradually progressing to the prescribed construction tasks. I used MathsPad to demonstrate construction procedures, guide students through the construction process, and provide opportunities for them to practice the tasks individually and collaboratively. My teaching also involved explaining construction steps, observing students as they

worked, responding to their difficulties, and encouraging them to develop their understanding through practical activities. After completing the first cycle, I reviewed the evidence collected through pre-tests, post-tests, classroom observations, student interviews, and my reflective journal to identify students' learning difficulties and evaluate the strengths and limitations of the intervention. Based on this reflection, I revised the lesson plans and teaching strategies for the second cycle by clarifying instructions, providing additional demonstrations, and increasing opportunities for guided and independent practice with MathsPad. I then implemented the revised lessons to examine how these changes supported students' engagement, confidence, conceptual understanding, and ability to perform geometric constructions. This iterative process of planning, acting, observing, and reflecting enabled me to respond to students' learning needs while critically examining and improving my own teaching practices as a teacher-researcher.

Research Site and Participants

The experiment was performed on one section of Grade X in a model public school in Birtamod Municipality of Jhapa district, Nepal. A total of 30 participants were involved in the classroom activity during the 15 days of action research. As the activity was done with the whole class, all the participants had an equal chance to get involved in the MathsPad-based learning activity. Before beginning the intervention, I assessed the pre-test performance, class participation, and past performance in the geometric construction of the learners in order to determine the learning needs. From the assessments conducted, I grouped the learners into three general learning categories, namely high-performing, average-performing, and poor-performing learners. The grouping helped in planning classroom assistance, promoting peer learning, and assessing the progress of the learners during the action research cycles. Whereas all 30 students took part in the intervention activity, six of them were selectively chosen to be the key participants for further qualitative analysis. This selection was done using the theory of maximum variation sampling, where two students were selected from each learning group – high, average, and poor performers. The participants were chosen because they possessed varied learning skills, class participation, as well as reactions towards MathsPad exercises. Moreover, they agreed to take part in interviews and disclose their learning experience. The choice of the six key participants has been made with consideration of the time limitation of the project too. It was impossible to conduct detailed interviews, write

reflective notes, and analyze the experiences of all 30 students during only 15 days of the action research period. Thus, by choosing six key participants, I managed to gather in-depth information, which is at the same time comprehensive and covers a wide range of experiences of learners of various academic levels. The profiles of the six key participants are provided below.

Saanvi

Sanvi is one of the innovative and encouraging students showing excellence in performance in grade X. Based on my observation, she is proficient in both the compulsory and optional mathematics subjects. Additionally, she is committed to participating in extra-curricular activities offered by the school. According to her peers, Sanvi is a collaborative group member. From our interaction, I obtained information about her family background and home environment. Few years ago, she lost her mother as a result of the COVID-19 pandemic in Delhi, India. She then moved to Nepal with her father together with other family members and enrolled in the school. Currently, she has been enrolled in this school since grade eight. In the course of the interview, it came out clearly that Sanvi is knowledgeable about mathematics and human beings. When asked, *"Have you experienced any challenges in your studies following the death of your mother?"* she smiled and replied, *"It happened unexpectedly, but I can manage to learn, knowing that this is part of nature."* She further explained that she enjoyed the geometric-construction classes more than her previous classes and found that using manipulative materials, particularly MathsPad, made geometric construction easier to understand.

According to her views, *"Even those learners who had some initial doubts showed confidence after watching the demonstration. It was challenging, yet fun because we could finally master it. Using the MathsPad was indeed revolutionary."* Through the interview, I learned how relevant and limited my action research on teaching geometric construction and importance of peer collaboration could be. Sanvi showed high participation in the action research process and contributed new ideas and techniques. She gave insights regarding action research process and experience in relation to study of reasonable achievement among children. She explained that step-by-step learning is a rewarding technique in understanding new concepts and knowledge.

Saanvi is one of the most energetic students in class. Looking at her past performance and current success in studies, she is a brilliant and hardworking student

in class. She explains her background as follows *"I am brought up in a learning family with skills such as financial decision-making, schedule management, and logical organizing ability."* According to Saanvi, digital learning has helped her learn more compared to manual learning techniques. As stated earlier, the use of a MathsPad helped her to visualize mathematics concepts. She explained how this technology has facilitated a realistic and interesting learning experience in mathematics.

Prajwal

Prajwal is a straightforward member of my action research team. He always helped in setting up projectors and other necessary machines for classroom lessons. He has been in this school since he was in grade eight. In the interview, he said:

> *My parents have always been encouraging towards me in all phases of my learning process. They are always motivating me to study, and they believe that mathematics is not only a subject but a useful skill which can lead to many prospects.*

He also pointed out that his parents motivated him to study hard and to be curious. According to him, he is inclined to learn more about practicing mathematics. To be specific, he said that among all topics in mathematics, geometric construction with a MathsPad is one of the favorite instructional units. Asked why, he explained that watching the demonstration of geometric constructions using the MathsPad makes him confident in carrying out the construction process. This is because visualization and active participation make him understand concepts well. Therefore, he is confident due to visualization and classroom interaction during the geometric construction process. He explained further, *"Mathematics is one of the most important subjects that help us understand the patterns and structures in the world we live in."*

Samita

Samita is one of the excellent students in the class who is very hard working. She was able to share her perspective and experiences of the whole process of learning through technology. Her parents were both literate people but not rich. They were humble, hardworking and satisfied with what they had. Their dream was to see her successful in life and they did whatever necessary to give her proper education. As she shared her experience with the researcher, she said that her parents were working hard to get her proper education and they admitted her in Mahendra Ratna Secondary School as they found it to be the best for her. The existing belief is that there have

been certain issues faced by both the students and teachers in some community schools when it comes to attendance and quality teaching/learning process.

In addition, the ability of a student to figure out the right learning techniques for himself is itself a personal achievement. It means self-realization and self-responsibility. Both these qualities should be encouraged in every child and every student. Speaking about her future plans, she said:

> *My family members have been supporting me from every step of my life so far. With their love, guidance and motivation, I will do my best and will keep my hope alive. My future dream is to do some good studies in order to make them proud someday.*

From this statement, it was clear that she would like to fulfill their parents' dreams. This helped to increase the motivation of the researcher to help her through action research.

Prashant

In this story, Prashant, an individual from Birtamode-3, Jhapa, talked about his personal journey in the processes of learning and development with the use of digital technologies. According to his own self-description, Prashant is a student who had a negative attitude towards academic subjects initially, which was strongly connected with his personal fears and insecurities. Being a comparatively rich person of a middle class, who could afford to get everything, he felt envious towards those peers, whose financial status was more stable than his. Speaking precisely, he said: *"I am jealous of my other rich friends."* Although such kind of experiences is not unique in students' life journeys, the key issue remains how one will cope with all difficulties and what will happen under the influence of surrounding circumstances. There is a crucial moment in Prashant's biography. Having studied at Funmin Boarding School before, he attended Mahendra Ratna School, where he met me and I helped him to overcome some obstacles, connected with the subject, and showed him the light at the end of the tunnel Previously, Prashant had a problem in solving complicated tasks and being embarrassed by the achievements of other students, while now he can easily find the solution to any issue. Thanks to that teacher, Prashant started using the MathsPad tool, which showed him how successful could be cooperation of learning, technologies, and fun. Such approach helped Prashant not only improve his mathematical skills but learn how to communicate.

Ashiwini

Ashiwini is an ambitious learner, supervised by me who has a passion for studying. The learner has suffered from health challenges that have at times interfered with her studies. Despite her current status, she is still a bright and competent learner. She said, *"I am always ready to learn new things no matter how I feel."* It has not been easy for her academically due to her status. Nevertheless, her persistence is notable. She expressed herself saying, *"Through such a technology, it will be easier for me to acquire the new thoughts and teachings of the class even if I am not present in the classroom."* This was one of the best developments that could help her succeed in her education. Ashiwini had much ambition, which surpassed the normal; she never gave up despite the difficulties and instead worked hard, an attribute not seen in many learners.

Neha

Neha is a good learner who does everything well with full concentration and dedication. She executes her tasks excellently and also undertakes lots of studies, but she finds it difficult to solve mathematics. She said among all subjects, mathematics is especially difficult since of its concepts. Previously she failed to solve most of the mathematics problems due to poor concept and knowledge base. In some instances, she wanted the mathematics program removed from school curriculum. After encountering challenges with geometric constructions, her frustration eased when she was introduced to construction software tools on MathsPad. After learning through the software, she had a great surprise of her perspective where the concept became easier to understand and the problems became easier to solve. She recommends the provision of the software to all learners in order to get a clearer result just like she did. The quote, *"nothing is difficult, you only need a new angle",* is evident in Neha's case. In my experience sometimes students tend to get bored and frustrated while doing the same thing using the same technique repeatedly from grade to grade. Therefore, instructors must change their approaches to suit different timeframes and trends.

Tools and Techniques Used for Data Collection

To gather comprehensive and varied information about the intervention and to develop a richer understanding of students' learning experiences, multiple qualitative data collection methods were employed, including interviews, classroom observations, reflective journals, and students' written work. Using multiple sources

of qualitative evidence can provide complementary perspectives on a phenomenon and strengthen the credibility of the findings through triangulation (Creswell & Poth, 2018; Merriam & Tisdell, 2016). Data have been gathered from various sources, which include the six important respondents, class observation, reflective journal, samples of students' work, pictures, and video recording. Also, semi-structured interviews have been done with the chosen students while informal discussion sessions have been held with mathematics teachers. In order to check the students' improvement, work samples and measures of performance were collected before and after implementing MathsPad. In collecting data, as per the intervention procedure, some time was spent on interviews with key participant students through semi-structured questionnaires. Below is the description of tools used in the process.

Reflective Journal

In the process of conducting research, I maintained a reflective journal to capture my reflections after each lesson based on the good things about the lessons conducted, students' challenges, and how the students responded to the MathsPad exercise. The journal served as an essential resource that facilitated further analysis and improvement in future instructions.

Photographs and Videos

To see how the learners learned in class, it was necessary to capture photographs and videos during the MathsPad activity in which students created geometrical figures, discussed among peers, and corrected themselves. The process made possible the evaluation of classroom processes and reflections regarding how the application should be used. The ethical issue that had to be considered included seeking authorization from the school management and permission from the students to capture their pictures and video recordings.

Field Notes

The collection of data about students' behavior and participation in the process was crucial for action research because it was necessary to record difficulties arising from the work with MathsPad and students' level of understanding. Thus, dynamic data obtained through observations helped to achieve study goals.

Samples of Student Work

In order to illustrate the effect of the implemented intervention, I documented samples of students' traditional drawings and works made with the help of MathsPad. In addition, I documented the results of the pre-tests and post-tests.

Semi-Structured Interviews

Data were collected through semi-structured interviews. Semi-structured interviews were useful because they helped me to understand the individuals' viewpoint of students concerning the effectiveness of MathsPad and problems faced by them in the process of using it.

Document Analysis

Document analysis was one of the data collection methods to understand the learning of students in the action research process. Among the documents collected were students' samples of work, practice notebooks, geometric construction practice, pre- and post-tests, and records of the MathsPad activity. This provided me with information on the conceptual and procedural mistakes of students, as well as the construction of geometric skills. I also analyzed my lesson plans and my reflective journal for the alignment of the planned activities and my teaching.

Data Analysis Procedures

By leveraging a range of qualitative data sources, including semi-structured interviews conducted with both the students and teachers involved in the process, work samples and performance data collected before and after the introduction of MathsPad technology, photos and videos recording classroom interactions, as well as the personal research journal, theme generation involved a manual thematic analysis approach. Firstly, audio recordings from interviews and visual data were transcribed to make it easier for the researcher to become familiar with the data set through repeated reading and viewing. Then, initial coding based on excerpts related to experiences using MathsPad, changes in the performance of the students, patterns of interaction within the classroom setting, and ethical considerations related to the use of photos and videos was created. After which, codes were combined into broader theme categories that included, as expected, student engagement, development of building skills, changes in pedagogy of the teachers, implementation issues, and ethical considerations. Data analysis was conducted right after each round of action research. During the 15-day intervention period, I was busy typing out interview transcripts, classroom dialogue, and my reflective journal while analyzing my classroom observation notes, students' work, photos, and videos. I read through the collected data several times to get to know the participants better and find relevant quotes for my research questions.

Following transcription, the data was analyzed by coding similar experiences and ideas. Codes were classified further into wider categories, which were then used to generate major themes. Such themes comprised students' learning experiences, involvement in class activities, understanding of concepts, difficulties that students encountered when creating geometrical shapes, and changes that occurred during the use of MathsPad. In addition, each of these themes was interpreted within the context of the theoretical framework, namely Vygotsky's Social Constructivism Theory and the notion of scaffolding, in addition to the personal experiences of the researcher. The credibility of the results was increased through the use of several sources of data, such as interviews, classroom observations, students' work samples, reflective journaling, and visual data gathered during the intervention period.

Ensuring Quality Standards

In every research study, researchers need to maintain a specific criterion. Quality and ethical standards are fundamental and essential to understand in conducting research. Initially, I maintained the quality standards to ensure the reliability and validity of the research findings. Rigorous research requires systematic and appropriate procedures for data collection and analysis to enhance the credibility, quality, and trustworthiness of the findings (Tracy, 2019). In my research study, the criteria that ensured the quality standards include trustworthiness (credibility, transferability, dependability and confirmability) and authenticity.

Credibility

To enhance the credibility of the research, I ensured that the data collected throughout the research process were closely connected to students' actual classroom experiences. I used multiple sources of evidence to compare and corroborate students' accounts, including their responses during interviews, my classroom observations, and their performance and work during the intervention. The use of multiple sources enabled me to analyze the consistency of the evidence and to gain an overall understanding of students' learning experiences (Creswell & Poth, 2018; Merriam & Tisdell, 2016). I also used the participants' actual words and specific examples of classroom activities in the data analysis to keep the findings grounded in what happened for the participants. I also kept a reflective journal during the 15-day action research process to reflect on my observations, experiences, reflections and decisions. Reflexively documenting this helped me be cognizant of my position as a teacher-

researcher, and part of the credibility and trustworthiness of being a teacher-researcher (Tracy, 2019).

Transferability

I gave detailed descriptions of the classroom setting, participants, teaching and learning processes, and the use of MathsPad across the 15 days of the intervention to increase the transferability of the findings. The reader can rely on the contextual and procedural details provided to understand the methodology used in the study and to decide whether the results can be extrapolated to other studies that have similar characteristics (Creswell & Poth, 2018; Merriam & Tisdell, 2016). I also included rich descriptions and concrete examples of students' learning experiences and classroom activities to help readers understand how the findings emerged from the intervention. Furthermore, the study focused on geometric construction, a topic included in the Grade 10 mathematics curriculum prescribed by the Curriculum Development Centre (CDC) of Nepal. Although the findings are situated within a particular classroom and cannot be assumed to be universally generalizable, the detailed description of the context, participants, intervention, and learning activities allows readers and other educators to judge the potential relevance of the findings to comparable mathematics learning environments (Tracy, 2019).

Dependability

To enhance the dependability of the study, I maintained consistency and transparency throughout the research process and systematically documented the procedures followed during the 15-day MathsPad intervention. All relevant classroom events, including interviews, observations, students' activities, and reflections, were documented throughout the intervention period. Audio and video recordings were also used, with appropriate consent, to preserve participants' responses and classroom interactions and to minimize the possibility of losing important details during data collection and analysis. In addition, the research procedures, data collection processes, and analytical decisions were reviewed by another researcher to provide external scrutiny and strengthen the dependability of the research process (Creswell & Poth, 2018; Merriam & Tisdell, 2016; Tracy, 2019). Maintaining systematic records and an audit trail of the research process further helped make the procedures transparent and traceable (Tracy, 2019).

Confirmability

To make sure the study's findings held up, I grounded my interpretations in real classroom evidence, not just my own opinions as a teacher-researcher. I paid close attention to what students actually did and experienced while working with MathsPad and building geometric objects. I pulled together several types of evidence interviews, classroom observation notes, students' work samples, and my reflective journal to support and double-check my interpretations. By drawing from different data sources, I made sure the results reflected what really happened instead of just my personal perspective (Creswell & Poth, 2018; Merriam & Tisdell, 2016). I also did member checking. I met with a handful of them and discussed my core interpretations with them and asked if that's an accurate reflection of them. This allowed them the opportunity to clarify, confirm or add to my analysis, so that the results were more credible and trustworthy (Tracy, 2019).

Thoughtful Teaching Critical Reflexivity

One of the things that I did regularly during this intervention was to take time out to reflect on my teaching practices, my students' responses and what additional strategies I needed to use in order to help my students fully understand the content. If students' growing evidence of difficulty was present in class and/or my own reflection, I would adjust MathsPad activities or change my strategy to assist students. The back and forth "trying something, seeing how it goes, then making adjustments" is consistent with the spirit of action research. Teachers carefully consider their practice, collect evidence, and inform future practice from that evidence (Kemmis, 2009; Mertler, 2020). This way, MathsPad didn't just stay static I kept shaping it around my students' real needs, especially as they worked on geometric constructions. I didn't just focus on my students I turned the lens on myself, too. I kept asking why I taught the way I did, questioned my assumptions, and reflected on the methods I used. Keeping a journal really made a difference. It realized me to identify my dual role as both teacher and researcher, and to stay aware of how that influenced my choices and interpretations.

Ethical Considerations

Ethical considerations are essential while conducting any kind of research. In this regard, throughout the whole process of conducting classroom action research, which lasted for 15 days, I paid attention to ethics. Before starting to conduct action research in my class, I obtained all the formal permission from the administration and

had discussions on how to conduct the research effectively with the mathematics teacher. Additionally, prior informed consent was obtained from the parents or legal guardians of the participating students before their participation in the study. The consent covered students' participation in the research and the collection and use of relevant research data, including interviews, audio and video recordings, and students' work samples, for research purposes (Creswell & Poth, 2018; Merriam & Tisdell, 2016). The students were also made aware of the study's objectives and the voluntary nature of their participation. Pseudonyms were adopted throughout the dissertation to maintain anonymity. While teaching students in the mathematics course, I equitably treated all 30 students, but selected six students who would participate actively and diversely in learning and understanding mathematical concepts using a MathsPad. I respected the privacy of students because personal identities remained confidential, and only the collected information was used for research purposes. During interview sessions, classroom interactions, recording of videos, and taking photographs, I ensured voluntary participation in the research process and obtained permission from students.

Chapter Summary

This chapter focused on the methodology that underpins the action research in investigating the use of MathsPads to improve geometric construction skills among Grade ten learners. In this section, the methodology used is described by considering the research design, where the qualitative action research is considered. Action research involves a continuous process of planning, acting, observing, and reflection in real-time in practical contexts. Therefore, the research design enables me to conduct action research as a teacher-researcher who uses different steps in conducting research in real-time. This research was done in one government school within the Jhapa district with a particular class of Grade X that incorporates MathsPad while teaching the CDC Construction chapter. The methods involve the description of the research setting, participants, and the purposeful selection of six students who are key in exploring the effect of MathsPads on improving construction skills among the students. The methodology involved the description of various data collection methods such as interviews, observation, field notes, reflective journal, student work samples, and audiovisual recording. In addition, the analysis of collected data is discussed, whereby thematic analysis was used in analyzing and interpreting collected data from different sources. Other issues, such as credibility, transferability,

reliability, confirmability, and ethical issues, were also taken care of during the intervention.

CHAPTER IV
INTERVENTION PROCESS AND RESULTS

In this chapter, the process and results of the intervention are presented. The main goal of the intervention was to improve the understanding and skills in geometric construction by using the MathsPad software. The chapter will include information regarding classroom activities performed, participation of the students and the changes occurred in the learning process. The implementation of the intervention was performed in two different cycles. In the first one, the attention was paid to the visualization and understanding of basic principles of geometric construction. During the second cycle, students worked intensively on geometric construction in the computer laboratory using MathsPad software. The aim of performing two cycles is to show the influence of digital MathsPad construction tools software, making geometric construction learning process more interactive and useful for Grade X students.

Baseline Data Collection before Intervention: Pre-Test Reflections

On Friday, 29 November 2024, I prepared the lesson plan myself to conduct the action research. The first day of action research began with a 15 marks pre-test to assess students' prior knowledge of geometric construction. The day of the test was notified to them, and they were informed to bring the necessary materials such as geometric box. That morning there was a pleasant ambiance in a peaceful school environment. After entering the school ground at 9:30 a.m., I saluted everyone saying *"Namaste"*. Head teacher inquired, *"When are you going to conduct your action research, Ram sir?"* My answer was, *"From today's first period onwards"*. Then he continued, *"Are you going to conduct it only with the students, Ram sir?"* I replied *"I am going to conduct action research only with the students of class X, section C*". This is action research not Participatory Action Research. Then the head teacher continued, *"Several teachers are absent today, so I have to arrange my class carefully"*. Teacher absenteeism and inadequate teacher management have been identified as challenges affecting the quality of education in Nepalese public schools (Kharel, 2017).

As soon as morning assembly ended, I went to my classroom to start my session. Students greeted me offering good morning, sir. Just after saying good

morning, setting my laptop with Interactive Panel Board, I questioned them, *"Are you ready for pre-test?"* Their reply was in unison, *"Yes sir"*. I continued asking, *"Do you have geometry box?"* Four students out of thirty remained silent without having the geometry box. One of them was a key-participant of this group. I moved towards those students and advised them to borrow geometry box from another class. Continuing the session as usual, Kesab sir came to the door and inquired me, *"Ram sir, are you conducting the pre-test?"* My answer was, *"Yes, we have started."* He silently entered into my class and seeing the question on interactive panel, he commented, "*These are easy questions; some are basic.*" I said, *"Yes, sir. Question no. 4 is based on Class X standard but others are basic."* Instantly one of the students arranged four geometric boxes from the next class and distributed. Two students got the geometry box from him silently, whereas one student thanked him.

Observing this incident, many questions popped out in my mind: Why these students don't have the geometric box? What is their economic condition? Are these students careless or do they not want to take the test seriously? How can I help these students to work effectively in the pre-test? Then I decided to observe their performance very carefully. I presented the questions to the participants on the interactive panel. The students became involved and started answering the pre-test questions. Some of the students required further clarification on the meaning of bisect while others asked if it was possible to bisect the lines through use of a ruler. From the discussion among the students, it appeared that the students found it challenging to answer the questions presented to them. The truth is that all the pre-test questions were meant to be answered through use of a compass to facilitate bisecting of the lines. After conducting the pre-test, I asked the students to give me their reflections on what they had just done. Almost all the students gave their reflections as follows:

> Saanvi: *When doing the pre-test, I got more anxious while measuring the line segments, and the result would be either longer or shorter than the right answer. This was the case despite the fact that I had used the scale several times before without knowing how to measure properly.*
>
> Neha: *Using the protractor in the pre-test, I got confused between using the outer and inner side of the protractor. Moreover, while drawing an angle of 60 degrees, I got a different value because I only knew how to do the steps but did not understand how the instrument worked*.

Prashant: *Both the bisection of the line segment and the angle was very difficult. I didn't know how to use the midpoint and compass, which led me to face problems in bisecting the given elements using construction techniques.*

Ashwini: *Drawing the straight lines was not an issue at all, but it was difficult to draw the angles with the compass and ruler, especially 75-degree angles. Bisecting angles was much more complicated, and I could not solve them in the pre-test.*

Kritika: *Doing the pre-test, I realized that I was not good at practical geometry, although I have learned this topic many times before and could not practice enough. I knew that the topic of geometric constructions included not only drawing but also understanding the concept itself.*

Prajwal: *Constructing a quadrilateral was a very complex process. It was difficult for me to know how to start, what lines to draw initially, and what to do next after constructing two lines.*

In relation to the pre-assessment process, there were clear indications of performance spread through the classroom in terms of reflections, which clearly showed that the majority of the participants needed to understand concepts and develop practical skills in performing geometric constructions. Most of the participants had problems in using the ruler, protractor, and compasses appropriately because they would use these materials without really having a proper understanding behind their usage. As a result, there was the need for the researcher to recognize that the skills needed by these students in measuring lines and angles would be seriously limited even if they needed to write the upcoming SEE. In my experience as a teacher, I have found the same problem among several students taking the SEE. Signs of low self-confidence and lack of hands-on experience were displayed when performing tasks of measuring, construction, bisecting, and sequencing geometric constructions (Sullivan & Heffernan, 2016), as evidenced by class observation notes, students' work samples, reflection journals, and photographs taken during the intervention period.

Teacher-Led Visualization with MathsPad

Firstly, in my class, I used a visualization strategy based on the use of MathsPad in order to conduct geometric constructions. It was intended to involve all participants into this learning process via a technological way. All construction steps were illustrated by me on an interactive board; after that, all students followed me and performed the same actions on their notebooks, where they made all the constructions

by themselves using rulers and compasses. Thus, this first stage of my action research involved digital visualization and the use of traditional geometric constructions. Dynamic illustrations in MathsPad helped students to understand complex issues better.

Conceptual Clarity from Digital Visualization

In my experience as a participant-researcher, I discovered that quite a number of the students started the pre-intervention period without clear knowledge on basic geometric construction concepts. For instance, most of them were found having problems when it came to the meaning of points, lines, line segments, loci, as well as bisecting lines and angles. What most of the learners did was to learn by rote-memorization, but never understood what was involved geometrically. Some of the learners had problems in the use of ruler, protractor, and compass when it came to solving geometry questions. This made them fearful and hesitant in dealing with geometry construction concepts. With time, visualization of geometric concepts became easier to achieve due to the application of stepwise methodological teaching using the MathsPad. This made the learners more active, interested, and confident in talking about geometric concepts. This theme is hence discussed under four sub-themes.

Conceptual Understanding of Point, Line & Locus through Digital Visualization

I started using the Digital MathsPad Tool for my Grade X geometry class on Sunday, December 1, 2024. We kicked things off with a quick chat about the word 'point.'

Teacher: Good morning, everyone. Before we dive into our geometric constructions, let me ask you what's a point?

Yugal: A point is a bindu, sir.

Teacher: Nicely put, Yugal. What do you mean by bindu?

Neha: It's a dot, sir.

(Some kids chuckled, while a few just looked confused.)

Teacher: Interesting. Okay, look at the screen.

(The teacher opened MathsPad and showed a bunch of dots on a yellow background.)

Teacher: Are these points?

Saanvi: Yes, sir.

Teacher: Yep, these are points. But in geometry, points have no length, width, or thickness.

Prashant: If points don't have any size, how do we see them?

Teacher: Great question, Prashant. Honestly, points aren't visible. The dots you see on the screen just help us picture where a point would be.

Shristi: So, a point is really just a spot in space, sir?

Teacher: Exactly. It marks a position.

Bibek: Why do we draw bigger points?

Teacher: Because we need something to see! Math deals with ideas, so diagrams help us make sense of things.

The above discussion provides evidence that it was a very important moment for assessing students' understanding of concepts. From the above dialogue, it is apparent that I initiated the discussion by asking: *"What is a point?"* A student answers saying, *"A bindu."* Another student says, *"A very small dot."* Some students laughed, while some kept quiet. This shows that their knowledge regarding the concept is not yet clear. Being a researcher-participant, the primary concern for me was providing conceptual teaching of geometric construction. For this purpose, I used the digital tool called MathsPad to illustrate the definition and concept of point.

Figure 1

MathsPad Interface Displaying Points

The concept of points, lines, and loci was introduced using digital visualization using MathsPad. At first, a point was explained as a spot in space with

no length, width, or thickness. However, immediately afterwards, students started posing questions. For instance, one of them asked: *"If a point has no size, how can we see it?"* This shows that the students' answers to questions indicated their misunderstanding of basic geometrical concepts. It is evident that the students viewed points not as abstract concepts but as dots with certain dimensions. Similar lack of understanding was observed in the discussion on lines and line segments. While Ashwini wondered whether lines and line segments were equal, Prashant considered a line segment to be part of a line. In the initial discussion on locus, the students had problems with grasping the concepts since they did not know how points moved, and what 'path' meant. Thus, an ant-walk was used as an example for demonstration of movements of points, and it was conducted using MathsPad. After that, students defined locus as *"a path made by moving objects."* This means that the visualization and discussion helped to resolve the students' confusion.

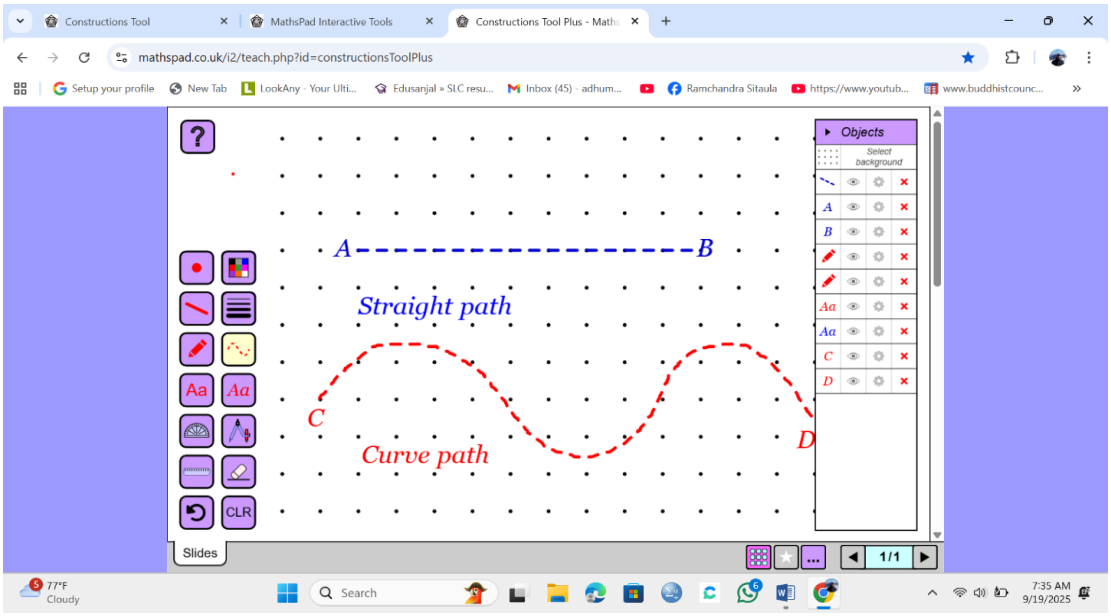
Students' confusion indicates the presence of gaps in their conceptualization of basic principles of geometry constructions. It is possible to relate it to the idea presented by Vygotsky (1978) that learners build up knowledge through social interaction and meaningful mediation. In this case, MathsPad became a mediating device that helped to transform learners' abstract confusion to visual understanding. Questions, like: *"How can we see a point?"* indicate cognitive dissonance, which is viewed by Vygotsky as an element of ZPD. Through explanations, illustrations, and visualization, learners gradually moved towards comprehension. Use of the example with ants helped students relate abstractions to their experience, thereby, supporting Kolb's (1984) theory of experiential learning according to which people learn through concrete experience. Furthermore, it became obvious that students understood geometry simply as a set of operations and processes. In this way, the visualization was helpful in forming understanding of connections between concepts, which relates to the theory of Skemp (1976) about two types of understanding: instrumental (memorization of information) and relational. Transition from textbooks' definitions to visualization also implies transition to a new educational paradigm based on constructivism. Kuhn's (1962) theory of scientific changes provides support for such claims.

In general, one can conclude that students did not regard geometry as abstract reasoning, but saw it as visual drawing of shapes. Questions, like *"Is a point really visible?"* indicated that students perceived geometrical terms in a concrete manner.

Thus, the statement that conceptual understanding requires mediating between abstraction and experience is proved. With the help of visualization provided by MathsPad, abstraction was transformed into concrete experience. Statements such as *"It is crystal clear now"* show that visualization helped learners overcome their confusion. This proves Vygotsky's assertion that social interaction and mediation with appropriate tools help people learn. Moreover, ant-example and dynamic images helped students visualize mathematics as movement rather than drawing. Therefore, these findings support Kolb's experiential learning theory, which posits that observations and experience contribute to the development of conceptual understanding. From another perspective, one should note that a paradigmatic shift in teaching process was also observed. Firstly, the instructor believed that definitions and explanations from textbooks would help students understand geometry. However, questions posed by student's show that this approach did not work, therefore, the teacher needed to use new tools. Kuhn (1962) argues that when existing approaches or paradigms are no longer able to adequately address emerging needs or challenges, a paradigm shift may become necessary.

Figure 2

MathsPad Interface Displaying Straight Line and Curved Line



I then showed them the figure joining the dots to demonstrate straight line and curved line using MathsPad creating the background of 'dots' along with the marching ants (kamila ko tati) as shown below.

Figure 3

Path Made by Marching Ants

Path made by marching ants.

Straight path → Straight line Curve path→ Curve line

One of the students said, *"It has been made clear that the path generated by the motion of an object or particle can be considered a locus."* Indeed! This is what we mean! Particles, while in motion, generate paths which take the form of many shapes or sizes, such as being straight, curved, circles, ellipses, parabolas, hyperbolas, or others. Other types of loci shall be introduced later on in your study, I replied after thirty minutes without wasting time anymore, I began differentiating between lines and line segments through the mathematical pad on the interactive board.

Visual Steps of Line Measurement and Bisection

In this interaction I moved to inquiry about line and line segment with the MathsPad visualization starting a short discussion as;

Teacher: *Which one is a line or line segment?*

Ashwini: *Sir, both are same looking.*

Teacher: *Fascinating. Does anybody else agree with this?*

Prashant: *No, sir. Line segment is part of line only.*

Teacher: *Well, done, Prashant. How would you differentiate between the two?*

Kritika: *Sir, the line segment is having two ends.*

Teacher: *Brilliant answer. How do you know the difference between a line and a line segment?*

Kamal: *It is infinite.*

Teacher: *Right. The teaching of math often involves symbols that are concise in meaning.*

Sunami: *Sir, no because there will be limits to paper size.*

Teacher: *Yes. Lines in mathematics are infinite but for the sake of representation we take limited portions.*

Saanvi: *Why is the construction difficult while copying but easy in MathsPad?*

Teacher: *Absolutely. Arrows show infinite extension in both directions.*

Prashant: *Then sir, line segment is limited because of two endpoints whereas lines have none?*

Teacher: *Right. A line is unlimited in length while line segment is fixed in size.*

Ashwini: *Got it. That is why both look alike.*

Teacher: *If that is the case, why do we represent lines with short lengths?*

Manita: *To symbolize infinity.*

Teacher: *Yes, math problems are often expressed using visualization techniques.*

Saanvi: *Why is there difficulty in construction when it is easy in MathsPad?*

Teacher: *Visualization helps to better observe motion.*

As per the lesson plan for Day 2, I had planned to start the class with the explanation of the answers to the pre-test questions. The course, however, took an unpredictable turn as the students were eager to ask a number of questions regarding the problems of geometric construction that they tried in the pre-test. Their eagerness to clear doubts made us spend around 45 minutes in the discussion, after which I could only cover Question 1 (a), (b), and (c) that dealt with measurement of line and line bisection. From the above scenario, it became clear that the students were really interested in knowing the concept rather than being told the right answer. The students had misconceptions about the way of constructing the shapes and the use of geometrical tools which proved that the students needed more conceptual explanation before proceeding to other concepts. From this class, it was made evident how important it is to give enough time for discussion and clearing up the misconception of students with the help of appropriate questionings and visuals. With regard to pre-test results, some students did line bisection with ruler and not the compasses. Some had trouble with line construction because of misconceptions. A student still had confusion related to measurement of lines. I was surprised by her assertion but upon further probing she confirmed the confusion. As a remedy, I asked her to construct a 5 cm long line segment using ruler and pencil. She followed my directions and made a 5 cm line segment as shown in Figure 5a from the non-zero end of scale instead of zero. With some help and scaffolding, she created a line segment as shown in Figure 5b. There was around 0.5 cm variation, as shown in Figure 5c.

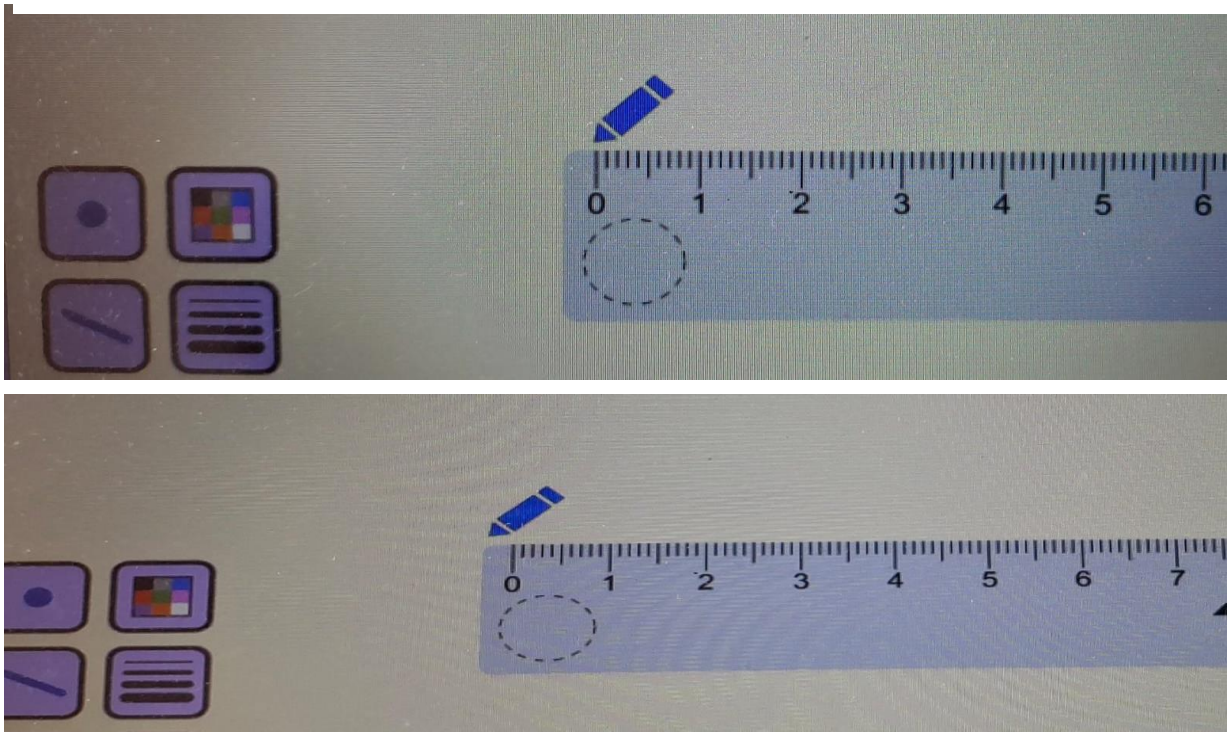
Figure 4

Visual Representation of Measuring a Line Segment

After observing her measurement, I realized that it should be demonstrated to all the participants to minimize such error I found in figure 4a, 4b, and 4c. Just after observing such error on her work, I visualized in interactive board for, how to measure line segments minimizing the error as shown below in figure 5.

Figure 5

Illustration of Correct and Incorrect Pencil Positioning

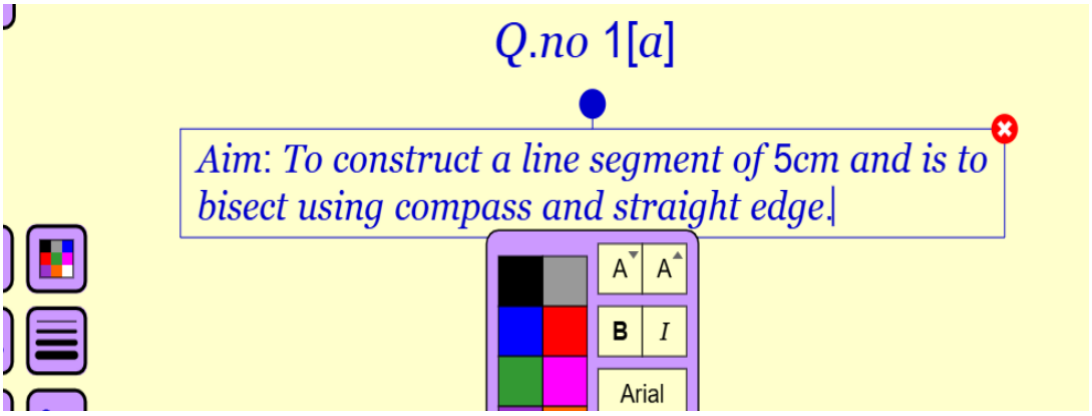


I then went ahead to show them how to measure a line segment and also how to bisect the same with just a pencil and a compass. After the presentation, most of the participants were grateful, they stated, “Sir, MathsPad is very good.” Upon asking why they said it was because the device would help them learn as it would make things very easy and fun to do. They mentioned being able to draw a line very easily as well as bisect it using a compass. Their explanation that everything about it made sense with little difficulties convinced me that indeed, drawings are helpful when it comes to understanding concepts in geometry. Such drawings act as their personal guide in the limited period of instructions. Having been encouraged by this, I went further and taught the participants how to bisect a 5 cm line segment using a compass and a ruler in accordance with pre-test question [1a].

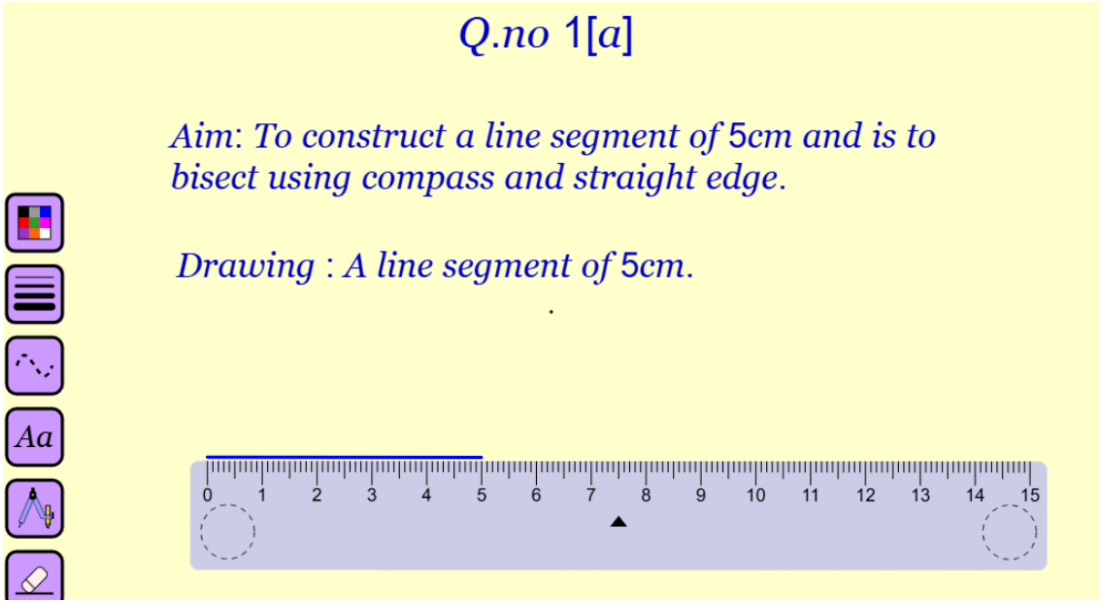
Figure 6

Demonstration How to Construct a Line Segment

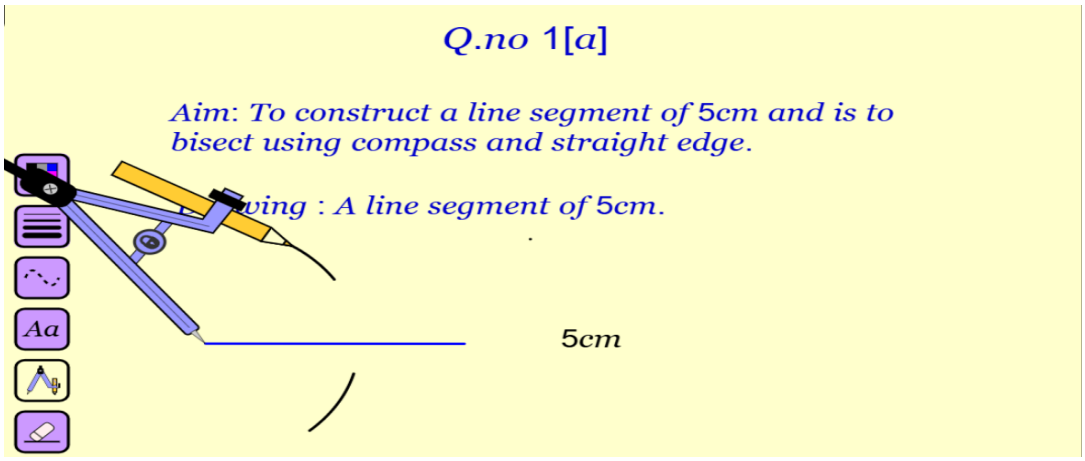
Step 1



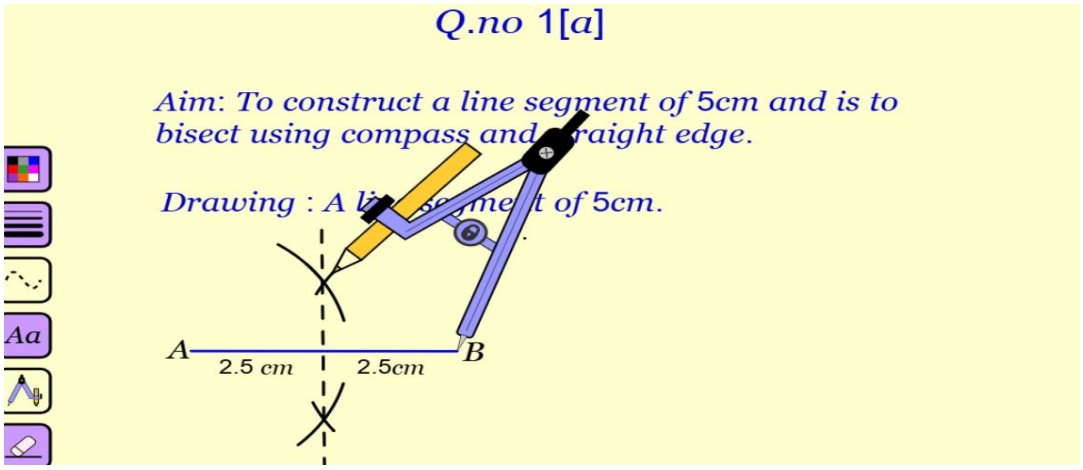
Step 2



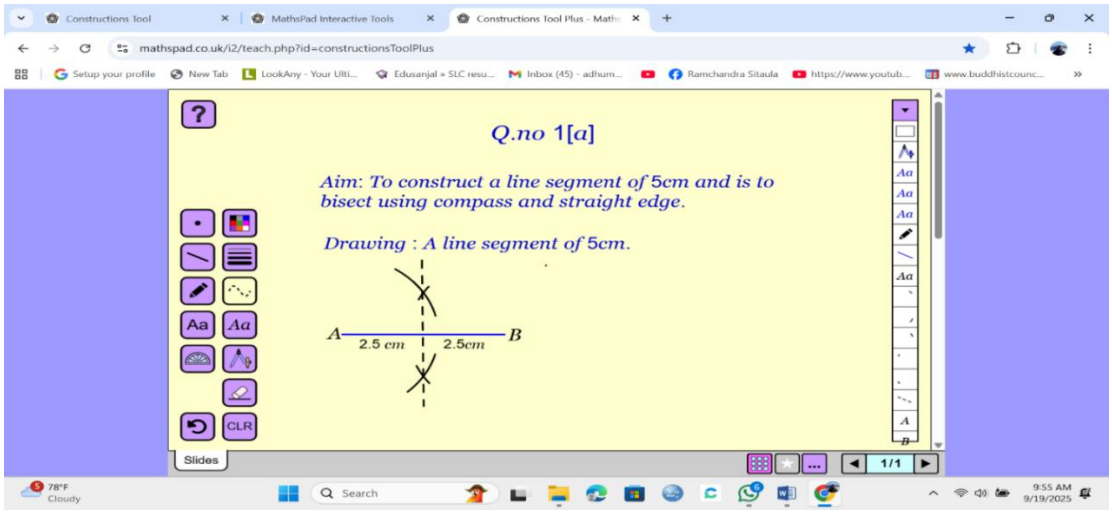
Step 3



Step 4



Step 5



Upon an exploratory investigation of the conceptual understanding of bisecting line segments using visualization techniques in MathsPad tool, Saanvi, who was a participant in this research, said, *"Oh! It is very simple, but I could not bisect the line in my previous pre-test examination."* The same sentiment was expressed by

all the participants. Then, I asked, *"Can you bisect the remaining line segments at home?"* All the participants responded positively, *"Yes, sir!"* This was a reconfirmation from the participants indicating that they felt capable of bisecting the lines, thanks to the visualization technique used by the MathsPad. Gaurav asked, "*Sir, could we use this tool on our phones*?" I replied that although they could do that, it was more comfortable using computers with mouse. I further noted that he would do that in the evening that day. At the end of the second day's lesson, I concluded the session and asked the students to complete a reflective writing task during the next scheduled class period. In the interactions, I made them discuss the concept of lines and line segments using MathsPad visualization technique. At first, the students had difficulties differentiating between a line and a line segment. Ashwini thought that both were the same, while Prashant thought that a line segment was a part of a line. With further questions, it was evident that students gradually understood that while a line never ends as it stretches indefinitely without any endpoint, a line segment has two end points. However, it was evident from the responses that the students' knowledge of infinity was limited, or their understanding was superficial. While explaining, the students realized that the textbooks represent lines as small segments as there are limitations of space. This indicates that students have a basic idea of abstraction in mathematics.

In the pre-test discussion, I observed that many students had difficulty with the basic concepts of constructions. A few students mismeasured line segments by starting their measurement from an incorrect scale mark, thus getting errors of around 0.5 cm. Some students even expressed inability to measure line segments. After understanding that problem area, I used visualization and scaffolding to help students learn about line bisection. As expected, the students were able to do the construction with accuracy after that. In the latter part of the discussion, students became more confident about constructing lines. The phrase "It becomes easier with MathsPad" and *"We can see each step easily"* were commonly heard phrases during the session. Hence, I noted that visualization played a significant role in increasing students' confidence levels.

Initially, students were confused with lines and line segments and also had trouble measuring line segments. The above situation indicates poor conceptual understanding of geometry. The situation conforms to Vygotsky's (1978) view that learning takes place by mediation, interaction, and scaffolding in the ZPD. The

current learning process involved use of MathsPad as a mediating tool. Moreover, it is evident that the mistakes committed by the students during measurement of line segments show instrumental learning without conceptual understanding. Skemp's (1976) explanation of instrumental and relational learning confirms this view. But after visualization, students started realizing the importance of measurements, hence shifting towards relational understanding. Lack of proper comprehension about infinite lines shows that students have difficulties with abstract thinking and require visualization. The usage of MathsPad helped students to relate abstract terms like infinity, locus, and lines with visual concepts, hence constructivist learning (Jonassen, 1999). This discussion also conformed to Kolb's (1984) experiential learning theory where students learned via observation (demonstration by teacher), practice, and reflection (feedback by the student).

This whole experience with the classroom indicates a gradual shift towards better pedagogy for improving students' conceptual understanding in geometry. From my experience in the present situation, I realized that the students considered geometry to be a set of procedures rather than concepts and relationships. However, with the help of visualization, the students came to know the actual process of bisecting lines. Their expressions of ease of understanding with MathsPad confirm the views of Vygotsky (1978). In addition, their correction of errors showed shifting towards relational understanding, as proposed (Skemp, 1976). Also, the students' connection of textbook concepts with practical measurement shows experiential learning. Hence, the overall experience in this regard shows a paradigm shift. According to Kuhn (1962), a paradigm shift occurs when existing methods fail. Here, when my traditional method of explanations proved unsuccessful, I changed my approach towards a newer one, i.e., digital visualization-based learning.

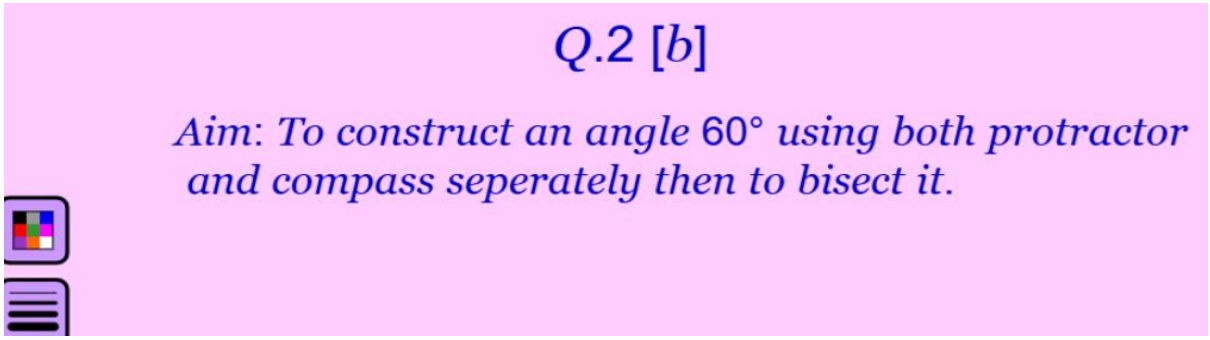
Angle Construction and Bisection with MathsPad

On Monday, 2 December 2024, I organized an intervention session on angle construction and angle bisector based on pre-test questions 2 and 3. I first connected my laptop to the interactive panel and showed the MathsPad applet showing the process of constructing a 60° angle both by using protractor and compass, as well as bisecting the angle.

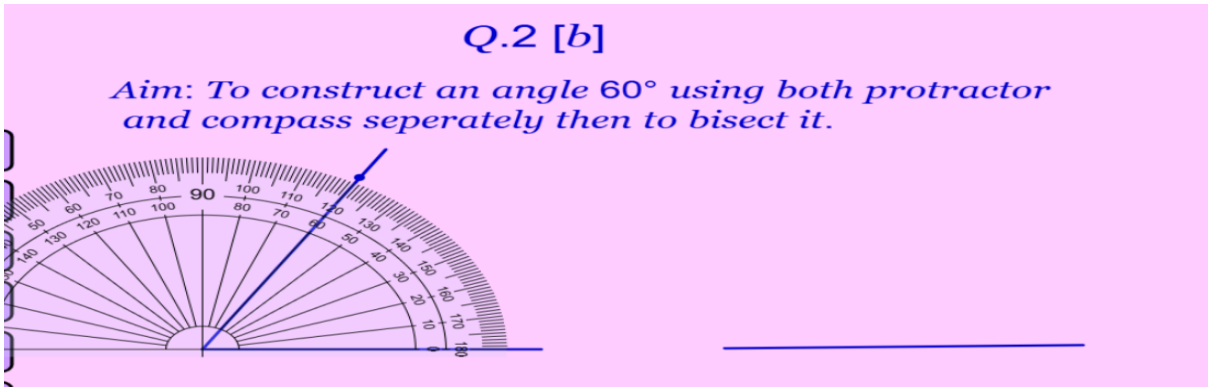
Figure 7

Demonstration of How to Construct an Angle of 60° Using Protractor

Step1



Step2



The intervention was on day 3 of the action research. I started the lesson with the aim of continuing the lesson on angle construction and equivalence of area. The students entered the class with great interest and one student raised the question, *"What is today's topic?"* Without answering him, Prashant, from the adjacent seat, raised the question, *"Sir, will you teach us angle bisection using a compass today?"* My answer to his question was, *"Yes, are you ready for angle bisection?"* They confirmed my response, and students arranged their geometry tools making some sound in the class.

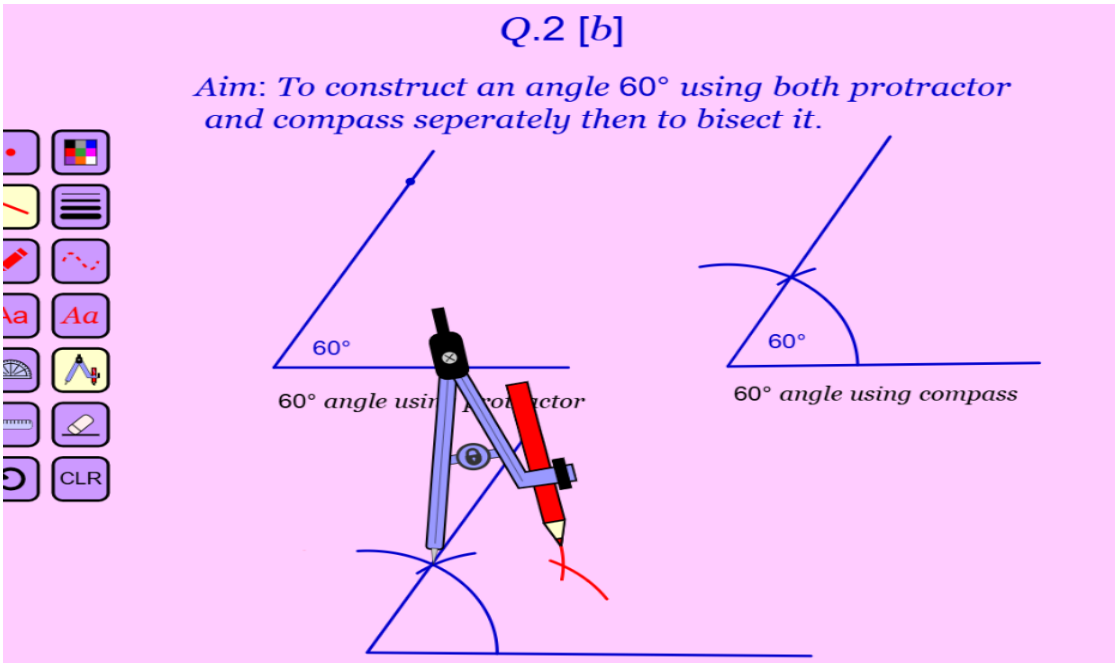
As a researcher, the lesson was started by introducing to the class that the focus for the day would be on the construction of angles using both the protractor and the compass. Using the MathsPad software, I constructed an angle using a protractor, then based on Question 2 from the pre-test, I constructed another angle but this time around using the compass and ruler as illustrated in Question 3 of the pre-test. Through the visualizations in MathsPad, I assisted the students to complete the construction steps, and from my observations, the students were actively following the steps as well as showing passion to compare the online construction with their

own pre-test experience. The corresponding diagrams for the construction are presented below.

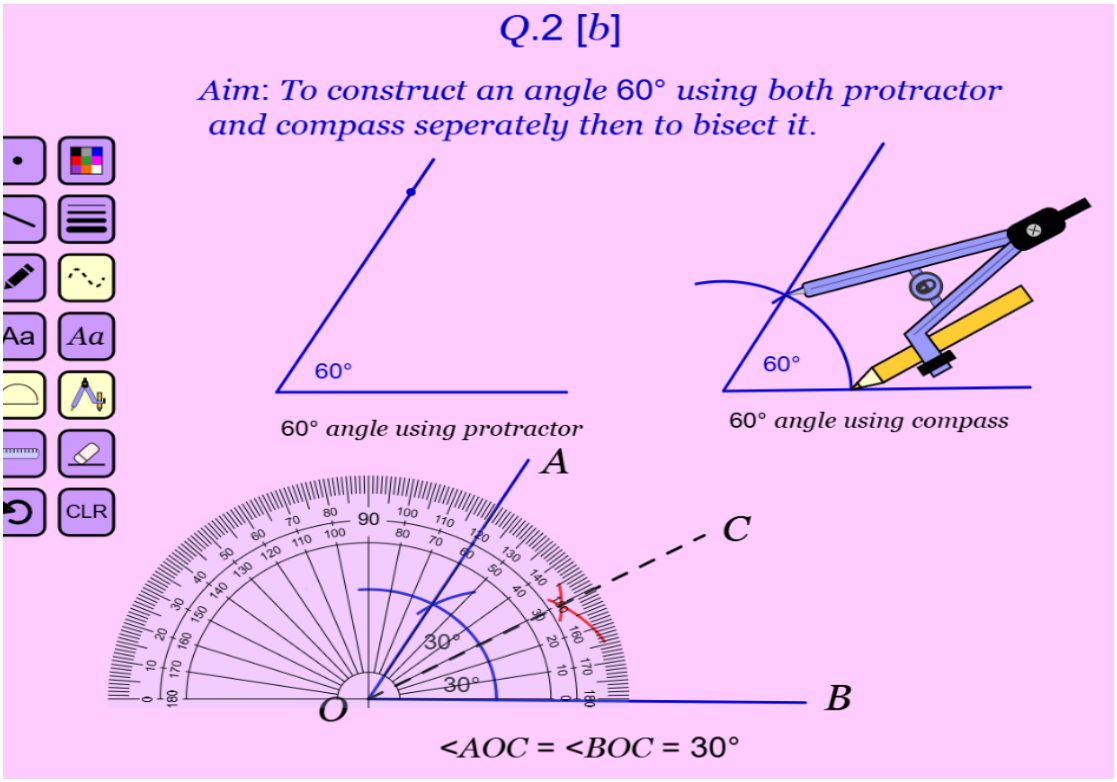
Figure 8

Demonstration of Construction of 60 Degree Using Compass

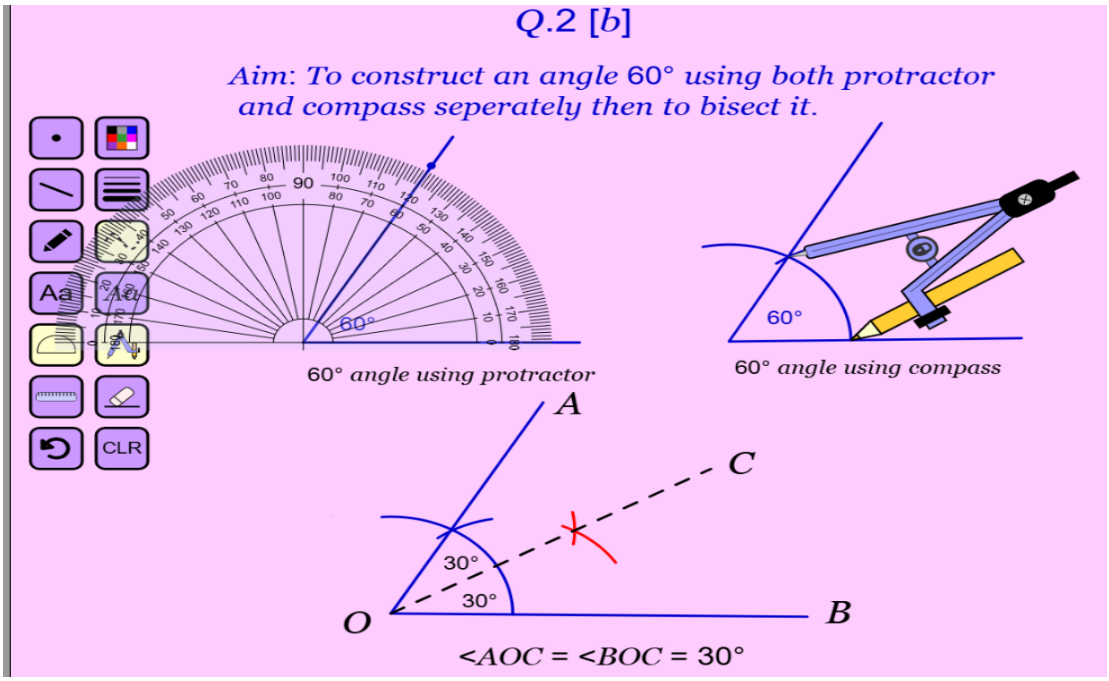
Step 1



Step 2



Step 3

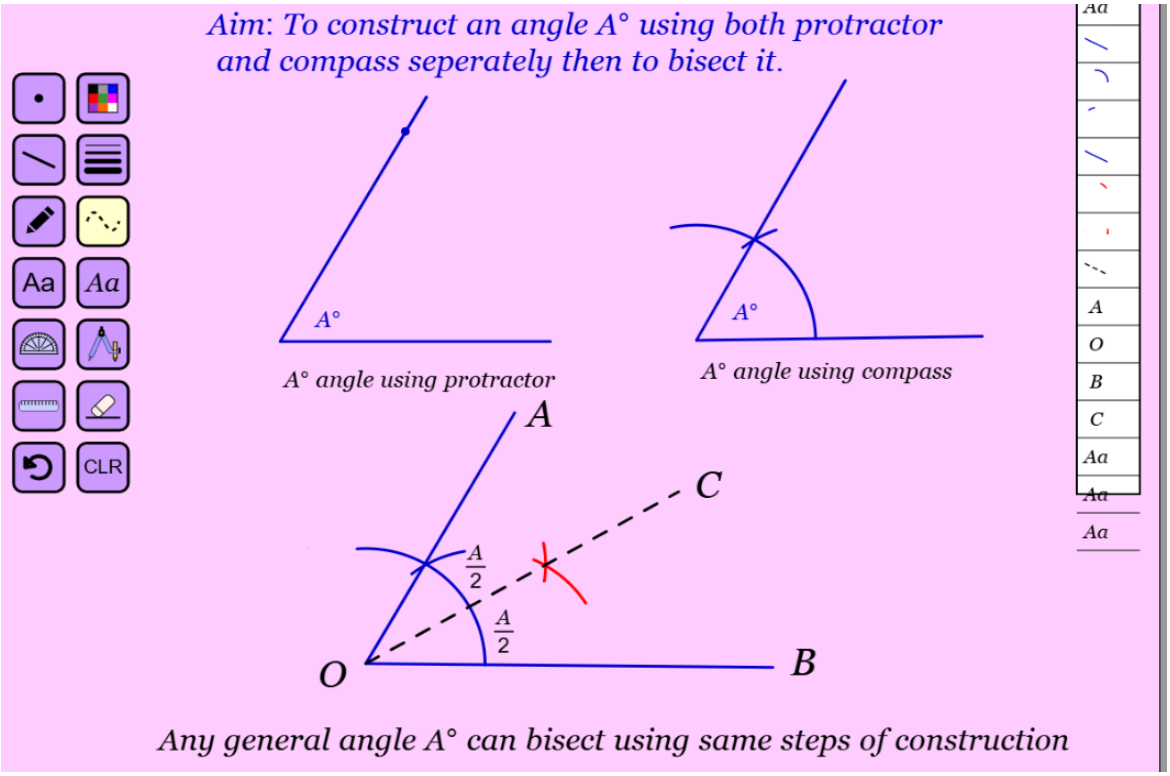


Saanvi said, *"The concept is very easy, but I was unable to do any construction using the compass during my last pre-test. Now, the whole concept regarding the construction of the angle by using the compass is quite clear to me."* Stepwise visualization with the MathsPad construction tool helped her comprehend the concept in a much better way. Firstly, with reference to the pre-test question set, I gave instruction about the demonstration of bisecting an angle through a compass, which was seen through the interactive whiteboard along with the help of the MathsPad construction tool. I drew a 60-degree angle through the compass and showed its bisection to make two angles each of 30 degrees in a sequential order, as shown in the following diagram.

As per Saanvi's feedback, the visualization process helped students understand the concept related to the construction of an angle and its bisection through the MathsPad construction tool. Thereafter, the next student, Prashant, posed a query, "Sir, is there any way of bisecting angles apart from the basic angles like 30°, 45°, 60°, 75°, and 180°?" I answered him, "Yes, as described in Figure 9."

Figure 9

Construction of Angle Using both Protector and Compass



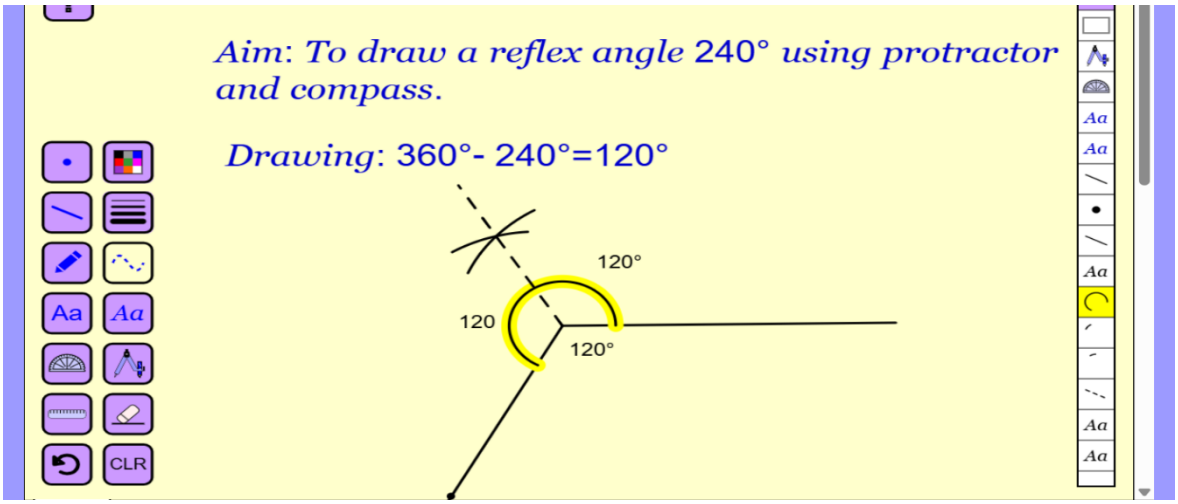
In the second day of teaching, it was observed that there was an improvement in the confidence level of the students as they worked on the digital MathsPad. All students showed significant effectiveness and participation via the tool through its step-by-step presentation. One student commented, *"Sir, we can see the steps in sequence. It becomes easier for us to construct and bisect the angles. Yesterday, I used the digital MathsPad tool and found it easy."* The rest of the questions were then answered by the students of the class.

Sikchya asked, *"Sir, how do we bisect an angle greater than 180 degrees?"* I said, *"Yes, we bisect reflex angle, i.e., an angle larger than 180 degrees in the same way as other angles." She further requested, "Sir, can you bisect a 240-degree angle?"* This was demonstrated as follows: *"We should first calculate the measure of the resultant angle, which is going to be 120 degrees."* By the end of Day 2, when I asked the students to construct and bisect angles with the help of the protractor and compass, I realized that many students were able to complete the process with more certainty and precision compared to the beginning of the session. This was also evident from the interview that Kritika had done, in which she informed me that the process of doing the activity several times helped her to better comprehend the

process. Another active participant, Yuna, stated, *"If given a chance to work on the MathsPad on the computer, we will be able to learn better."* I appreciated the comment of Yuna and said, *"Yes, definitely. We will utilize the facilities provided by the school and fulfill your wish as soon as we finish our first intervention of action research."*

Figure 10

Construction of Reflex Angle Using Compass



Finally, Ashwini asked, *"What will be discussed tomorrow, sir?"* I told them we would start geometric constructions of quadrilaterals and triangles having the same area as in question number 4 and stressed the importance of such a topic from the standpoint of SEE. To this, another student said, *"Sir, then it should be learned in detail in our upcoming classes."* She then asked, "*Why are you teaching us like this? We have never been taught like this before in our past classes."* I smiled and told her that I am doing action research on this. *"Sir, what is action research? Why are you doing it?"* she asked. To this, I replied, *"It is a technique of research in any topic whatever."* The student was curious and asked, *"Do we have to do this in future also, sir?" "Surely, yes; if you plan to study education after your school life, you will encounter this technique,"* I told her. The class became livelier with the emergence of some unpredictable questions from them. These questions and eagerness of mine to answer them gave me motivation I had not expected before. I answered the questions on syllabus topics as well as on those out of syllabus topics. Then the bell rang, signaling the end of our class almost at the conclusion of Day 3.

On the second day of intervention, I taught how to construct angle and bisect it using MathsPad visualization techniques. First, I constructed an angle of 60°, both

using a protractor and a compass. Thereafter, I showed step by step how to make a bisection from this, making two equal angles of 30° and 30°. Students took keen interest in it, showing readiness to engage in activities using instrument and the concerned questions as well. While teaching, the students showed much active involvement with me. Prashant asked me if we could teach angle bisection with the help of compass as well. After my assurance about this activity, they started watching MathsPad dynamics and doing their work in their exercise books simultaneously. Saanvi realized that angle construction with the help of compass became *'crystal clear'* for her now since she used to face a lot of difficulties in doing so during the pre-test. Likewise, many of them told me that such a step-by-step demonstration made them understand the whole process of construction. They extended their thinking further by asking about bisecting nonstandard angles or reflex angles. Someone even suggested that I should construct a reflex angle of 240° for them. Thus, at the end of this class also they showed increasing confidence in constructing angles and doing their bisection with them.

At the beginning of the activity, I noticed that there was confusion among students regarding angle construction since this is instrumental learning. But, once they started watching step by step demonstration, they gained insight into the rationale of this process. This was possible because of the Mediating Tool Theory of Learning (Vygotsky, 1978) as proposed where learning occurs via social interactions and mediating tools in the Zone of Proximal Development. In our intervention, MathsPad becomes the mediating tool through which students have learned about constructing angles conceptually. Since they faced difficulties in doing so in the pre-test class, it seems that they were following instrumental approach in angle construction. This was changed after they started getting a grasp on this concept through visualization. It shows the distinction made by on relational understanding vs instrumental understanding of a topic. Here, the students came across relational learning due to which they started posing higher order questions like bisecting reflex or nonstandard angles (Skemp,1976). Thus, as per Kolb (1984), the experiential learning theory, learning occurs when one observes something, participates actively in it and reflects upon it.

Overall, there is paradigm shift in terms of pedagogy in this classroom due to the adoption of constructivist theory. Students have started participating actively by posing questions and showing curiosity to learn. The overall trend has become from

rote learning to constructivist approach of learning. Thus, it can be concluded that in this intervention, students did not take geometrical construction as a process but as a concept itself. Their statements, such as *"It is crystal clear now"* and *"we can see steps one by one,"* indicated that visualization helped them change confusion to understanding. The students found MathsPad helpful for observing every step of construction dynamics that reduced their cognitive difficulties. As per Vygotsky (1978), learning was done using a Mediating Tool in the Zone of Proximal Development (ZPD). The students, here, started posing complex questions regarding geometric ideas, which means that they developed relational understanding of concepts (Skemp,1976). Moreover, I also experienced paradigm shift in my teaching. Initially, I used to depend upon explanation only, but the confusion of students regarding the pre-test context forced me to think of visualization technique. This follows the ideas of Thomas Kuhn on the emergence of paradigm shifts whenever a new problem confronts us despite the existence of existing solutions. So, there was paradigm shift from conventional geometrical instructions to new visualizations supported by MathsPad.

Increased Engagement and Motivation

With the continued implementation of the intervention strategy, there was a noticeable improvement in students' motivation and engagement when learning geometric constructions. Through visualization using MathsPad, the creation of an engaging learning environment was made possible where the learners participated actively as opposed to simply listening to their teacher. The learners asked questions, gave suggestions, and showed interest in the various steps involved in geometric constructions. Students who had always kept silent in class started taking part in discussions and making attempts to construct the geometric figures. This increased level of motivation resulted in learners undertaking practice even outside class. This theme was described under the following sub-themes.

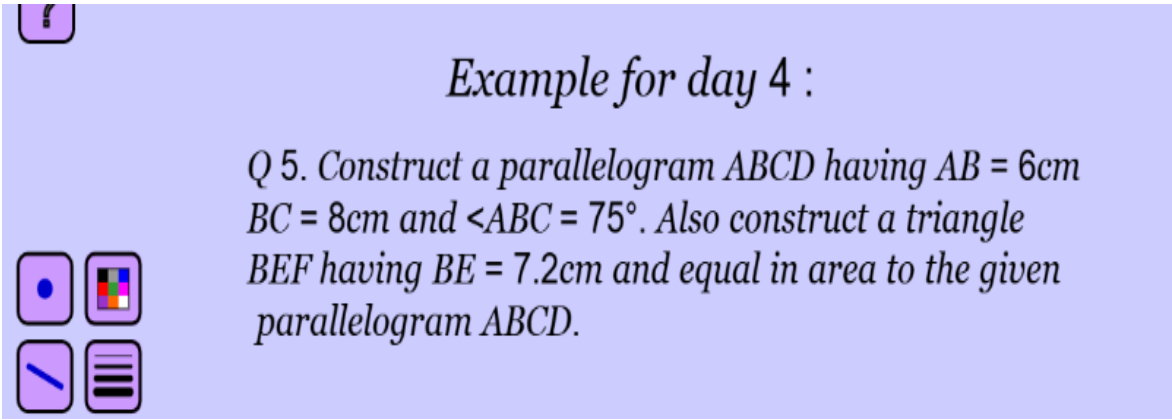
Active Engagement through Interactive MathsPad Visualization

On Wednesday, 3 December 2024, the fourth day of the action research process began. The main aim of the learning process on Day 4 was constructing a triangle whose area is equivalent to the area of the parallelogram. The open question raised was, *"Are you ready to construct the parallelogram?"* All students gave a positive answer. The students were eager to construct the area of both the parallelogram and the triangle. As a researcher, I was optimistic about their ability to

solve the problems on Day 4 because from previous experience, the students would not have any difficulties solving the problem. It was demonstrated how to construct both shapes through an illustration as below.

Figure 11

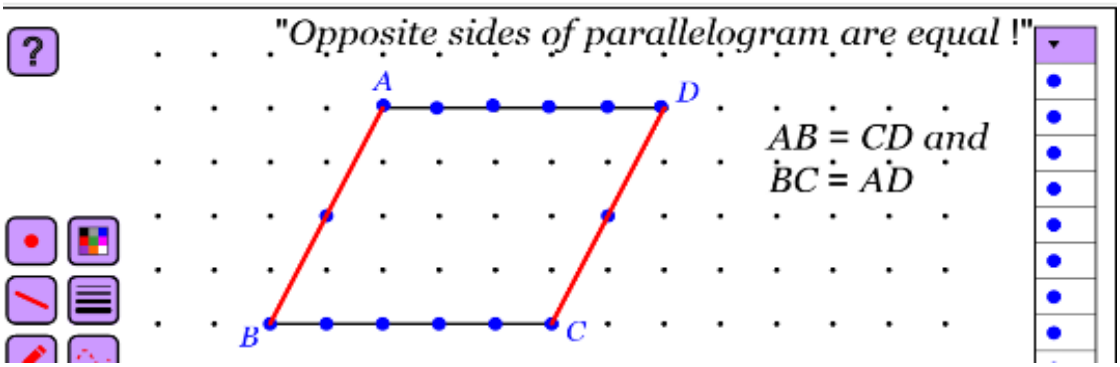
A Complete Construction Question Asked in SEE



While performing the task, Neha, one of the student participants, asked, *"Why are there only two sides? Is it not essential to provide four sides as in the case of a quadrilateral? How can we construct if only two sides are provided? I am puzzled."* To which, I replied, *"Don't be worried; your query is highly relevant."* Thereafter, I prompted all the participants to think over her question, asking, *"Please explain your concept."* Saanvi, a dedicated peer, responded by saying, *"Opposite sides of a parallelogram are equal."* Further, I explained, *"As pointed out by Saanvi, when two sides of a parallelogram are provided, the other two are equal."* In order to resolve their confusion, I demonstrated the characteristics of a parallelogram using the math-pad interactive panel board by placing dots, as illustrated below.

Figure 12

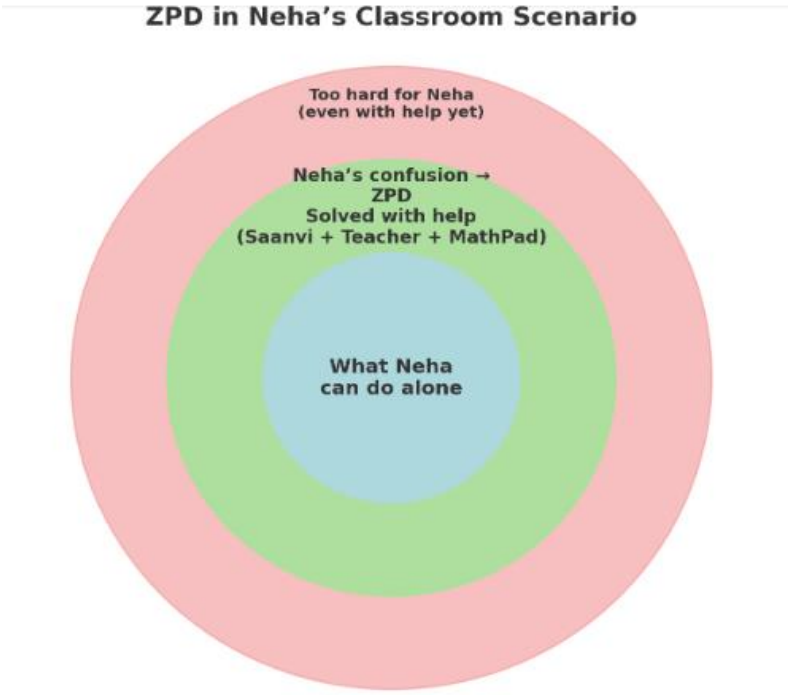
Construction of Parallelogram Using MathsPad



The current classroom example can be described as an application of Vygotsky's Sociocultural Theory of Learning. The state of confusion played a vital role as an impulse to social communication and explanations from other students. By presenting her confused state during the lesson, Neha was put into the ZPD where she would not be able to solve the task on her own but she could achieve that goal if assisted by her classmate, Saanvi. According to Vygotsky (1978), learning emerges through social interactions and mediation within the ZPD. My duty was to elaborate on clarification and include relevant rules of mathematics into the equation. It illustrates how learning takes place by means of communication, cooperation, and utilization of cultural artifacts (MathsPad in the current case).

Figure 13

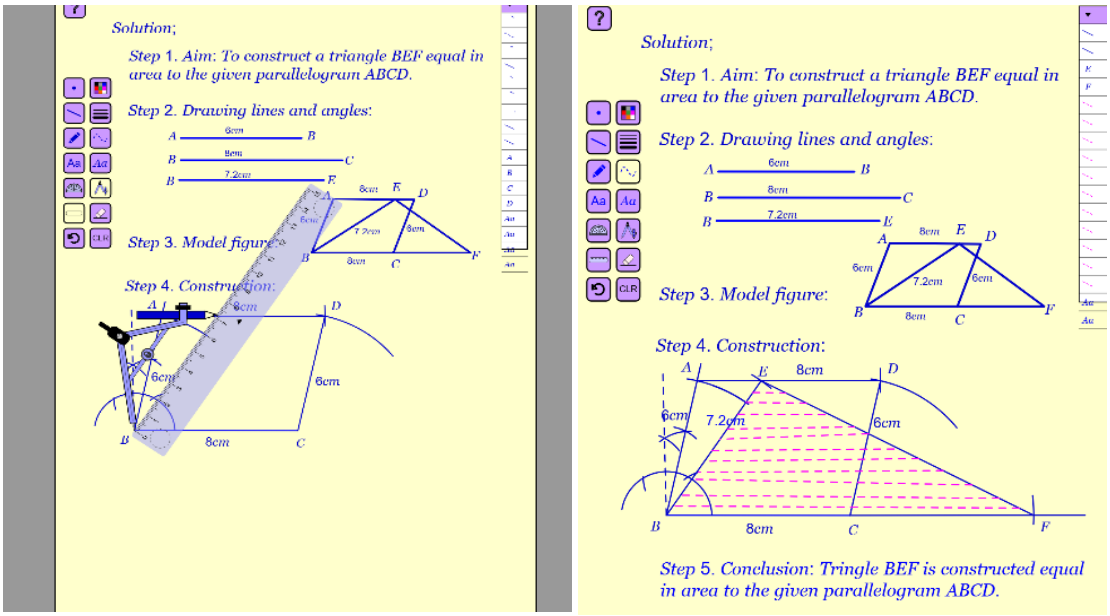
ZPD in Neha's Classroom Scenario



The pre-construction interaction leading up to the Question 5 of class instruction on day four was definitely very good. I started right away on constructing and guiding students through the steps in a sequential manner through visualization. The atmosphere in class immediately became silent with intense concentration among students on completing their own work while being highly involved.

Figure 14

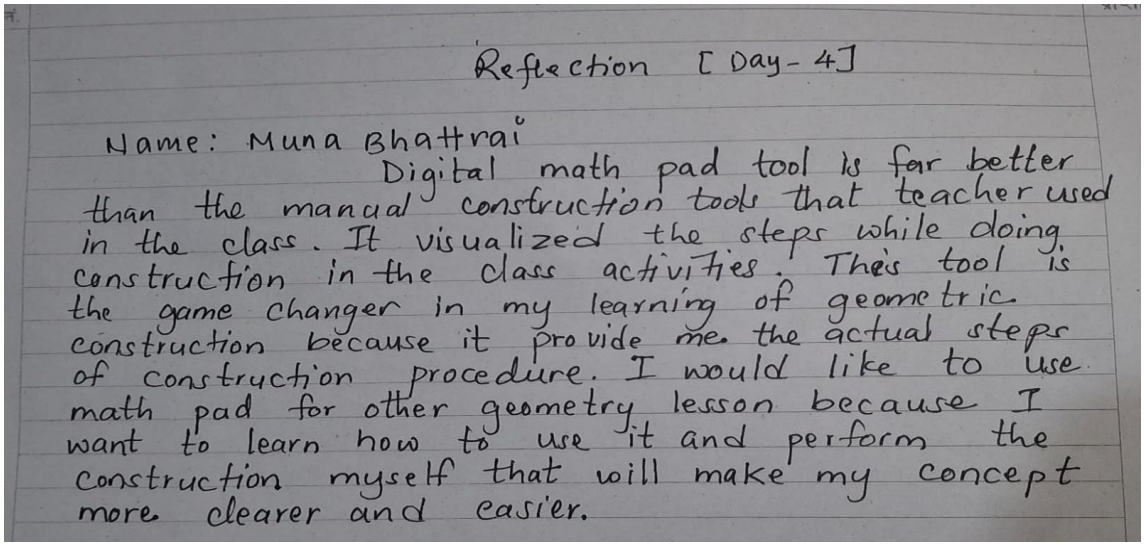
Picture Representation of Complete Construction



After completing the solution of question number 5 with proper explanation I requested my participants to write reflection of day-4 class based on their entire learning journey with experiences. While collecting the reflections of my participants two of them expressed their experiences as in figure 15.

Figure 15

Students' Reflections on the Effectiveness of MathsPad



Reflection [Day-4]

Name: Muna Bhattrai

Digital math pad tool is far better than the manual construction tools that teacher used in the class. It visualized the steps while doing construction in the class activities. This tool is the game changer in my learning of geometric construction because it provide me the actual steps of construction procedure. I would like to use math pad for other geometry lesson because I want to learn how to use it and perform the construction myself that will make my concept more clearer and easier.

I observed that increased comprehension may help build the confidence of students as they progress step-by-step in visualizing geometrical construction. In the voice of Muna and Yuna, MathsPad aided the participants in visualizing the individual steps in such a way that it facilitated geometrical construction and helped boost their

confidence. According to Vygotsky's (1978) theory of sociocultural, the scholars can benefit from the instructional support provided by tools and teachers (Shabani, 2016). MathsPad worked as an instructional tool that showed procedural steps in the form of instructional guidance. On the other hand, the help of teachers acted as scaffolding that kept the learners inside the zone of proximal development (ZPD) to perform the tasks. Peer collaboration further contributed to boosting confidence in performing the geometrical construction.

One participant asked me that that, *"Sir, from which day shall we use MathsPad in the lab? There is no Internet connection in the lab."* Another asked that, *"Sir, will you take us once the Internet becomes accessible?"* I said:

> *We will require two more days to complete the other tasks of the first intervention. Afterward, I will give you the second intervention in the lab where you will perform the geometrical construction practically by using the MathsPad Construction Tool yourselves.*

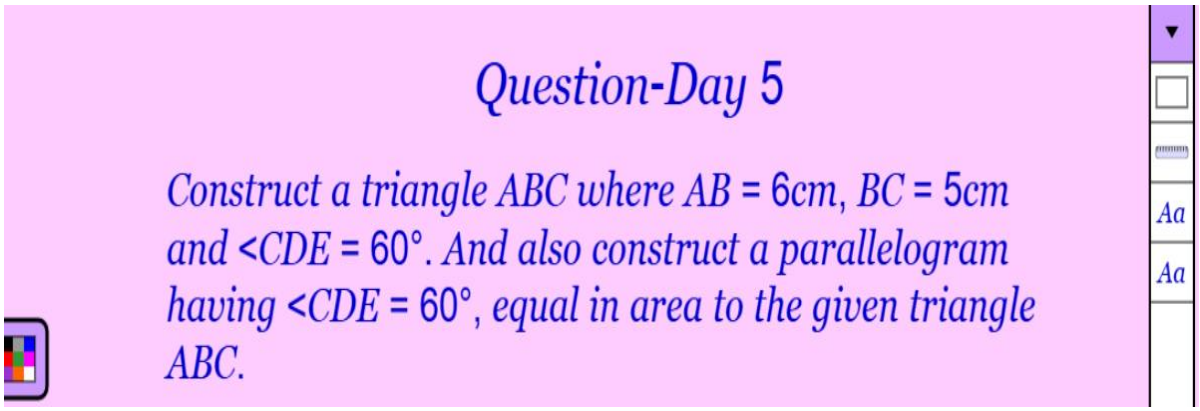
All participants were excited about this announcement and shouted, "WOW! That's nice." This made me think of how motivated the new generation could be toward learning to do geometric construction with the aid of technology. This was definitely a milestone in my teaching career since the students would do geometric constructions using the MathsPad application not with the conventional geometric tools, paper-pen approach, and submit their work in the PDF format. Here, I introduced MathsPad as a cultural tool according to Vygotsky's (1978) theory of sociocultural. Excitingly, the change of paradigm from paper-pen to the digital world occurred quite unexpectedly. I considered Kathmandu University and the participants responsible for bringing this turning point in practice. I encouraged the participants to let them know that they would be the first batch of digital constructors who would perform geometrical constructions without using paper-pen and without the geometry box. I reminded those four participants who had remained quiet before the intervention for the lack of a geometry box that they would never need to borrow any geometry box since digital geometric construction through MathsPad is possible now. Hearing that, their confidence increased as did their level of participation. They were quite eager in their replies. However, I was well aware of the arrangement of the laboratory and internet connection there.

Thursday, December 4th, 2024, was one of those crisp, sunny winter days that instantly lifts your mood. I parked my motorbike at school and headed into the

classroom. A few girls were already inside, and as soon as I walked in, they greeted me. One of them piped up, *"Sir, what are we learning today?"* I smiled and told them we'd be working on constructing a parallelogram with the same area as a given triangle pretty much picking up right where we left off in the last class. They replied that *"Sir, okay, so we shall do similar things today, right?" "Yes,"* I replied. Then I entered the class with manual and digital resources. I started with their learning experiences in doing geometrical construction in the previous classes, the Future challenges and opportunities were discussed. It seemed that all participants were ready to take part in geometrical construction, as the class was full of the sound of geometry tools.

Figure 16

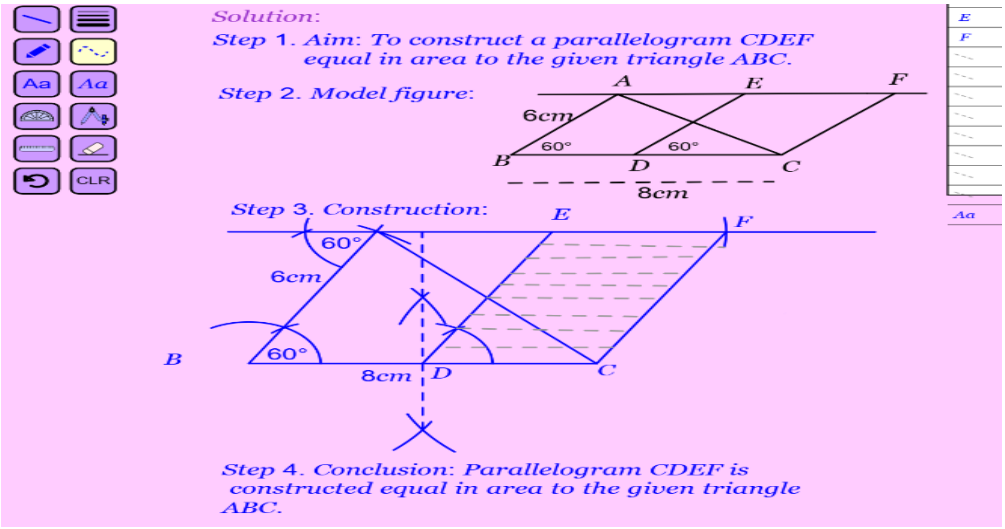
Construction Question for Day 5



Being a researcher, I noticed that there was an obvious growth of confidence and satisfaction while doing geometric construction. At the beginning of the interventions, the participants had difficulties while drafting the construction; however, they needed my assistance constantly. On the other hand, once MathsPad visualization became included into the process of the interventions, the participants managed to construct geometric shapes independently. The participants who used to be silent before the interventions started to take active participation in the process of geometric construction. Thus, I decided to start geometrical construction using such questions:

Figure 17

Step by Step Visualization Using MathsPad



My inquiry began as a conversation with a friendly student named Sikchya, who said,

> *Normally, I sleep off in the geometry class, but today I was very excited about watching each construction step on the screen. I wanted to try myself at the next step too. When the teacher asked me to make a prediction of the next step, I tried making it quickly because I wanted to confirm my idea. It feels like playing games.*

To that, I responded, *"Very good! I am calling upon the silent participants too. What do you think?" They answered, "We are having fun."*

On the fourth day of the intervention, I noted that it created a very interactive and collaborative learning environment in the mathematics classroom. From the very beginning of the lesson, when I asked the participants to make a parallelogram, they replied with enthusiasm and confidence. This indicates that previous lessons have been able to build their readiness and motivation towards geometric construction. With the help of the MathsPad visualization tool, students remained active throughout the lesson. When introducing the problem to students, Neha became puzzled as to why we would be using just two sides for constructing a parallelogram. As a researcher, it was important to me that the students express their misunderstandings through digital visualization. I chose not to provide any answers right away and allowed the participants to think and discuss the problem themselves. It was Saanvi who said that the opposite sides of a parallelogram are of the same size. Using the visualization tool, I drew a parallelogram on the panel board in front of the students.

Observing the whole thing, I realized that students' involvement increases if mathematical concepts are presented to them visually. During the construction process, the participants kept quiet, trying to figure out each step. In the reflections collected after class, the students told me that they felt more confident with geometric construction after the visualization exercise. They also mentioned that the use of MathsPad helped them visualize each construction step and thus gain more knowledge about parallelograms. Moreover, I could see that the participants became interested in learning geometry. In the past, I noticed limited enthusiasm among my students with respect to constructing geometrical figures using paper and pencil. However, today I saw my students motivated and engaged in the task of digital construction in the computer laboratory. It became clear to me that a new learning culture emerges in the mathematics class, and the participants wanted to learn geometry digitally through MathsPad. In my professional career, it is the first time I see such excitement among my students in geometry classes. Likewise, Sikchya's reflections indicated that interactive visualization made students engaged and interested in learning geometry. She described herself as being very active and interested in predicting the next step on the screen.

Interacting with Neha, Saanvi, and the teacher, one can apply the sociocultural theory of learning introduced by Vygotsky (1978). He suggested that learners develop their cognition through social interaction and collaboration and with the use of specific learning aids (Vygotsky, 1978). In this case, Neha's confusion helped the class members engage in cooperative learning, which led to clarification of a geometrical concept. The explanation made by Saanvi acted as peer scaffolding, and the MathsPad visualization tool operated as a cultural learning tool in ZPD. Such findings corroborate the assumption of Shabani (2016) that learners can accomplish difficult cognitive tasks if they receive appropriate scaffolding and guidance. In the current intervention, the teacher's guidance and digital tools used by the researcher helped students understand geometrical properties better.

Students feel more motivated to join in activities with visualization, which lines up with what constructivist learning is all about. Constructivism says students learn best when they jump in, share ideas, argue their points, and work together with others (Vygotsky, 1978). The visualization tool helped with that. Instead of just sitting back and watching, students took charge. They guessed each construction step, checked their answers with their classmates, and got involved in real discussions. That

hands-on approach made them true participants in their own learning. The comments made by Muna, Yuna, and Sikchya coincide with results of studies that investigated the effects of technology integration in math classes. These students found dynamic software helpful in terms of becoming more confident and interested in learning mathematics. The visualization made it easier to connect concepts and steps involved in constructing figures; thus, it made the process interesting for participants. Besides, they wanted to do construction in the computer laboratory to practice what they learned during the class. Overall, there were gradual changes in which the participants began to move from using the paper-and-pencil method only to becoming an active part of the technologically-supported learning environment. In terms of the TPACK model, this change indicated the successful integration of technological, pedagogical, and content knowledge. With the help of MathsPad, relevant instructional approaches, and geometric construction ideas, I managed to provide students with the opportunity to learn how to visualize constructions, get instant feedback, and understand geometry better. Hence, the study results revealed that technology turned into a useful learning tool due to its proper integration with pedagogy and mathematics.

So, after this intervention, I picked up a few key things about how digital visualization impacts learning geometric constructions. For starters, using MathsPad to walk through each step really got everyone more involved in class. Students actually wanted to watch and join in because the concepts just made more sense to them. You could see their interest growing as they started to follow along and take part more actively. Secondly, peer interaction contributed to learning as students clarified geometrical notions in cooperation. In particular, my observations support sociocultural theories according to which learning takes place through peer interaction (Vygotsky, 1978). Thirdly, digital visualization reduced their anxiety and confusion in geometry class as they could follow construction steps more easily. Such results support the notion of scaffolding, as they show positive outcomes under guided conditions (Shabani, 2016). One more lesson I learned is that the attitudes towards learning geometry change with interactive methods. Students who showed lack of interest and reluctance towards geometry class became active and emotionally engaged. Some of them compared learning to constructing shapes to games because they were interested in making predictions and verifying them. Finally, the lesson demonstrated that incorporating technologies into math instruction helps shift traditional ways of learning and teaching mathematics towards innovative practices.

Development of Confidence and Enjoyment in Geometric Construction

In this case, participants gradually gained confidence and interest in geometric construction with help of digital visualization using MathsPad, which helped clarify each stage of construction and minimize their fear of making errors. On Friday morning, December 5, 2024, I was heading to coach some participants when a few students waved and stopped to chat. One girl told me she'd been working with MathsPad and had practiced all the pre-test questions except for the fourth one, which she said was tough for her before. Hearing that made me genuinely happy. It's great to see her getting more interested and sticking with something new. Then I questioned them, *"And how about you all?"* They replied*, "Yes, sir". We have practiced."* One student called Prajal said that, *"I practiced at home using my computer. Actually, sir, I would say that I prefer using MathsPad to learn with the computer than using traditional methods of geometry set."* On asking him the reasons for his preference, he further responded,

> *Actually, when I started using these tools like compass, scale, protractor, I was having trouble in doing so, but as I continued, I became skillful. Since our generation spends most of the time on screens, it is a good combination of fun and learning.*

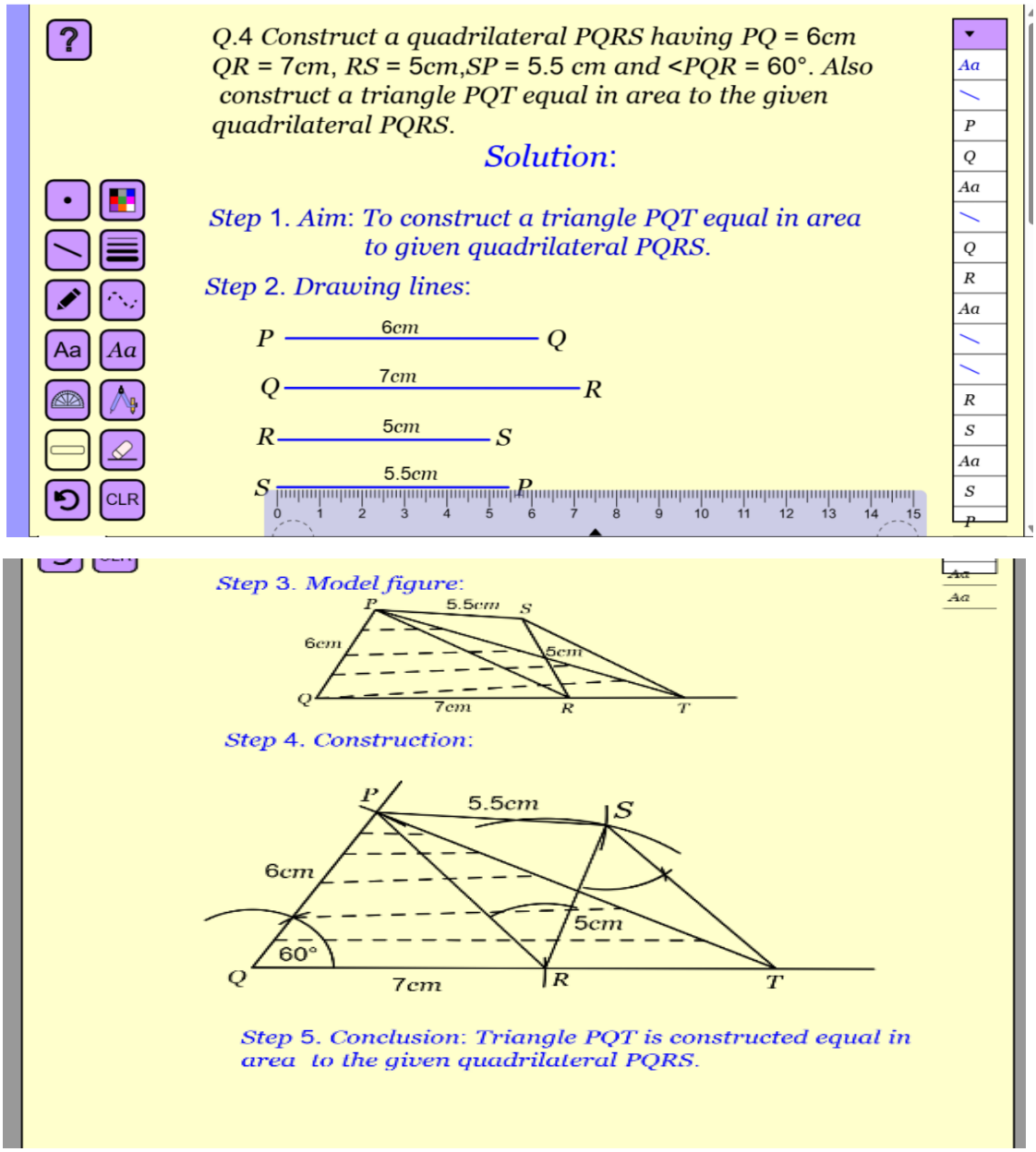
Yuna also expressed happiness by telling, "*Sir, even my six years old brother uses MathsPad*." I questioned her about the use of MathsPad by her brother, and she replied, *"Actually, he tries to make houses using this software, and I think we can teach other young learners using this technique."* I positively responded and told that we might think about it for our future lessons. From this conversation, I perceived that the students were gaining confidence, familiarity, and enthusiasm about using the MathsPad construction software. In this regard, as a participant-researcher, I found that the students gradually gained confidence and interest in geometric construction through regular practice of MathsPad. Moreover, through reflection, the students expressed that the process was interesting enough and minimized their fear of construction of different shapes.

From the perspective of constructivism theory, this observation implied that students learn through an active process and repeated practice. From the socio-constructivism point of view, interaction and sharing of their experiences helped build students' confidence. Reflections of the students also showed that they were finding

digital learning interesting and entertaining, and hence their interest and involvement increased.

Figure 18

Construction of a Quadrilateral and a Triangle with Equal Area



Following the presentation of Question 4 on MathsPad, I encouraged the students to get ready for the upcoming process. The classroom was arranged in an organized manner when we commenced, and the classroom became energetic and loud just like a marketplace where students are seen chatting, opening and closing geometry boxes, noise of pencils and ruler hitting the desks, peers borrowing materials, and so forth. These activities recalled me of the school days. After some

time, I asked them to calm down and concentrate on the lesson. While demonstrating each step of geometric construction on MathsPad, students started to do what I showed them using their geometric materials. Gradually, students became organized and concentrated on the process. The construction of Question 4 happened successfully without any problem. Following the completion of the process, I began to walk around the class and saw whether there is something wrong in their construction or not.

Almost all the students did the class activity without facing any difficulty, and they seemed more comfortable with the visualization. As a part of data collection, I asked one of the students about the difference in skill before and after learning the new concept. Mebin said that the action research done by the teacher helped the students more than the teacher because, previously, he used to have difficulty in learning mathematics and had despair. However, now he feels happy about his daily development due to the ongoing action research. Another student agreed with him and told that the introduced tool is helping him to learn better. It was encouraging and motivating for me to hear their views as those responses helped me to gain more confidence towards the study. The classroom scenario gave me an indication that their engagement helped me in approaching the goal. Nearly all of the students finished their work, while some were almost finishing during my observation. Their completed work was presented on the interactive board as shown in Figure 18.

Following the process of Question 4, students wrote reflective writing of their experiences of geometric construction. The classroom was quiet at first until one student, Mabin, handed over his reflection piece and started talking to me. He says, *"Sir, if this teaching method will be used in other parts of mathematics, studying will be interesting and we will understand." Asking how, he said, "It is easier for us to see and learn from the board."* According to Mabin, learning geometry became more interesting and easier compared to the previous lessons. The statement given by Mabin shows that the digitalized visualization on the interactive board made learning easy and reduced the difficulty to understand the procedures. Therefore, it can be said that the new teaching strategy motivated students to engage in learning mathematics. From the above discussion, it can be said that learning through visualization enhances comprehension and increases motivation among learners.

From my point of view, the active and loud classroom represented their engagement and interest in learning. This phenomenon corresponds to the theory of

Vygotsky because of the high level of social interaction among participants. The social interactions took place when students cooperated, exchanged materials, discussed, and worked together on the assignment. The introduction of MathsPad enabled them to concentrate more on the process and follow the procedures. This indicates the idea of Bruner's scaffolding theory and Mayer's multimedia learning. In addition, dynamic visualization provided an easier way for students to understand each construction step by step and thus made them more relaxed and engaged in the learning process. Based on students' reflections, repeated success in performing tasks was a reason for building more confidence and independently solving similar problems. The findings are consistent with Self-Efficacy Theory developed by Bandura (1997) and the idea that students gain confidence in their skills due to successful learning experiences and task mastery. In addition, the use of visualization and guided exploration allowed students to build their understanding of geometric concepts, which is in line with the theory of social constructivism developed by Vygotsky (1978), as well as with Anghileri (2006)'s definition of this theory. Being a teacher-researcher, I was able to reflect on students' responses and adjust my teaching strategies during the intervention period, thus developing professionally. Growing Interest in Digital Learning and ICT Integration

Growing Interest in Digital Learning and ICT Integration

As a teacher-researcher, I noticed the rising interest of learners in digital learning. The use of MathsPad and visualizing step-by-step activities led to better clarity, involvement, and understanding in mathematics. Over time, positive attitudes towards the incorporation of ICTs in learning geometry emerged. Also, there was a clear expression of willingness to use digital technology in other mathematical concepts. On Sunday, December 7, 2024, I led a discussion with the students about using ICTs in geometry lessons. Things got a little tense when Saanvi, one of my brightest students, asked for help with question 11.1(A) from Activity 1 in the CDC Mathematics book (page 211). I asked if everyone was ready to get started, and they said yes. To kick things off, I used the “write” option in the MathsPad app to copy over the question for everyone to see.

Teacher: *Today, we’re going to learn how to construct a parallelogram with the same area as another shape using MathsPad. Who wants to give it a shot?*

Saanvi: *Sir, can I start by drawing the base line?*

Teacher: *Go ahead, Saanvi. Draw AB with a length of 4 cm.*

I watched as Saanvi used the ruler tool in MathsPad to draw a careful, precise line.

Saanvi: *Drawing with this technology is just easier—seeing the measurements right on the screen helps way more than using paper.*

Teacher: *Great point, Saanvi. What about the rest of you? How do you find it?*

Yuna: *Sir, I see points and lines clearly. When drawing on paper, sometimes I get lost while constructing parallel lines.*

As the participating teacher-researcher, I realized that learners had a high level of concentration on the screen as they awaited turns to work with the MathsPad digital technology.

Teacher: *How do we draw angle ABC to measure 60°? Can you tell me why?*

Neha: *The question says to construct angle ABC. The middle letter tells you where the angle's vertex is.*

Teacher: *That's right, Neha. You're on the right track.*

I could see all the students paying close attention to the steps.

Prashant: *Sir, when I draw the lines using the digital tool, I can already picture the whole parallelogram before I even finish.*

Teacher: *Exactly. That's visualization. Digital tools make it so much easier to see and understand what's happening in math.*

While we extended the top line to build another parallelogram, everyone started getting more curious. They began to wonder how two shapes that look different could still have exactly the same area.

Teacher: What has to stay the same if their areas are equal?

Mabin: *Sir, I think the height has to stay the same, even if the base changes.*

Teacher: *Good thinking, Mabin. What made you say that?*

Mabin: *When I moved the points along those parallel lines, the distance between the lines didn't change, so the space the height was always constant.*

At this point, there was more interaction within the classroom regarding geometrical concepts. Learners were not only following procedures but also reasoning conceptually through visualization of geometrical concepts.

Yuna: "*Sir, MathsPad has made the concept of geometry fun because one can visualize all steps".*

Neha: *"Yes, and mistakes can be resolved quickly without making learners nervous while constructing the diagrams".*

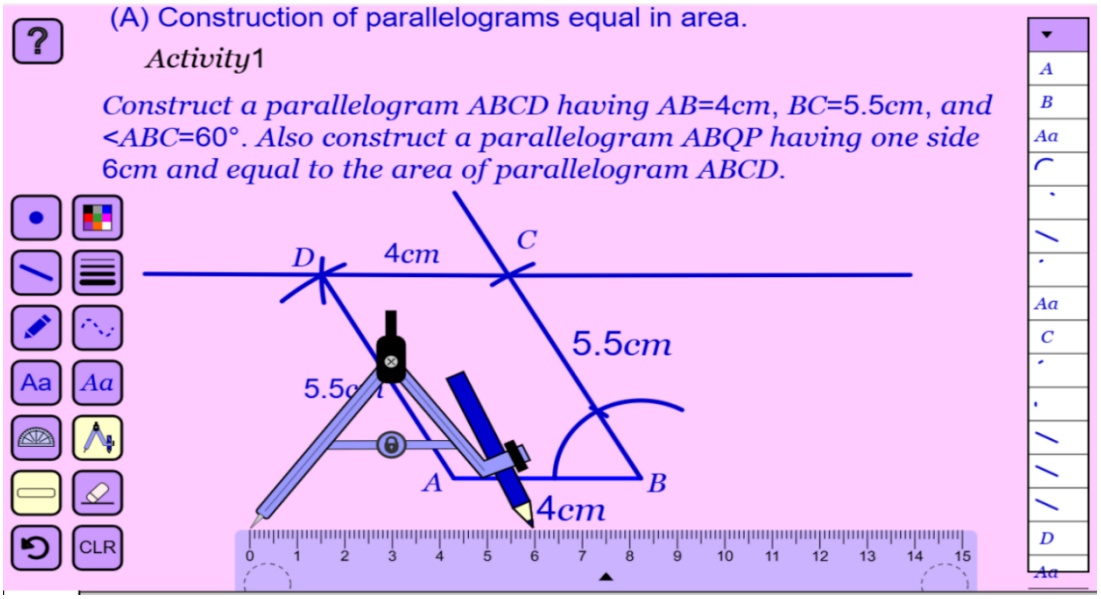
Teacher: *"Should digital tools be used to teach other mathematics concepts?"*

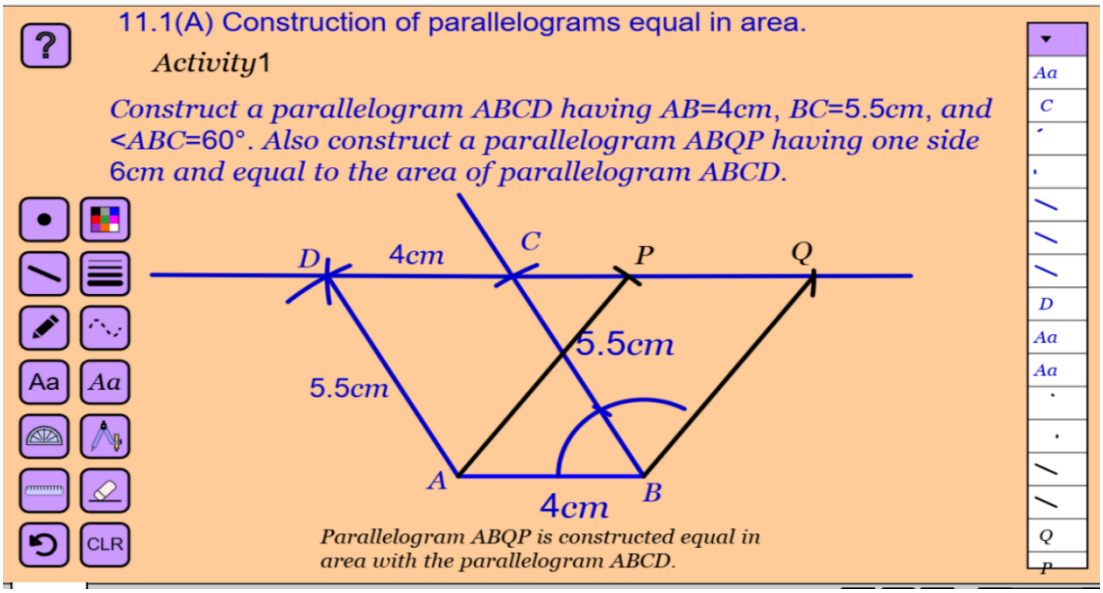
Prashant*: "Yes, sir. It is through regular lessons taught via digital technology that mathematics becomes easier".*

Saanvi: *"Sir, learners become more concentrated when lessons are taught using this mode because it feels realistic".*

Figure 19

Construction of Parallelograms with Equal Area Using MathsPad





During Activity 1 on constructing parallelograms equal in area using MathsPad, I observed growing curiosity and excitement among my participants toward digital learning and ICT integration. Papert's constructionism theory explains

that learning becomes more meaningful when learners actively create and explore ideas using technological tools. The visual movement of lines, accurate measurements, and interactive construction process created an engaging learning environment where students actively participated and discussed mathematical ideas confidently.

Just after completing the solution of question number 4, I saved the solution in PDF. It was seen by participants but one of the student names Samita Sarki surprised and asked me *"Sir Can I submit such PDF file after completing this question at home in my computer?*" I replied *sure,* then you can submit such PDF via email. Another student asked*, what to do if we don't have computer at home?* One of his friends added*, sir, we can't use computer of our school lab.* Understanding the interest and self-confident of the participants, I need to know their excitement so I asked, *how many of you can practice at home please raise your hand?* In my question answer only two students raised their hand. This noted that 28 more participants do not have access of devices at home. They could not digitally practice geometric construction at home. The overall conversation of my participants signified that all are interested to practice on computer. Hearing their voice, I thought, how my participants can have such excess of computer and internet in lab to practice geometric construction on MathsPad? If they were able to practice geometric construction in computer laboratory, they can download or screen short the solution and directly submitted to me via any social media. From this action research participants not only learned geometric construction but they developed skill to use digital MathsPad construction tool for learning geometric construction.

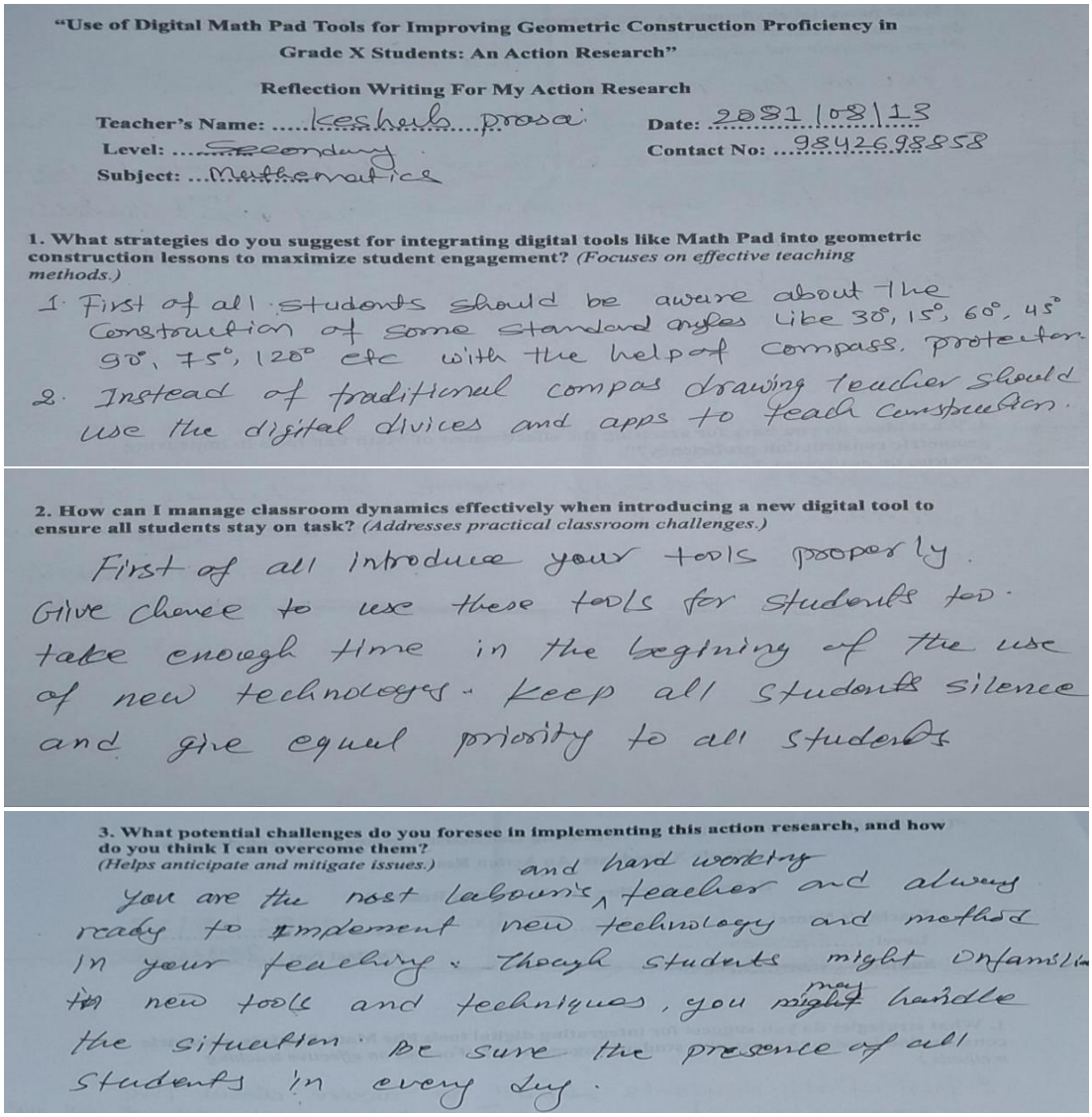
It was an unexpected scenario. Initially, I developed my action plan just to teach geometric construction for grade X students integrating MathsPad construction tools. On moving till seventh day of teaching, they learned many things starting from a point (.) till the area equivalent of triangle with given quadrilateral (pre-test question no 4) and activity 1. I tried to specify the need and further interests of the participants; I found that all of them wished to practice geometric construction on computer themselves either individually or in a peer. Almost all my co-researchers ethically forced me to provide such opportunity during this journey of my action research**.** If participants given opportunity to use computers and able to submit construction digitally using MathsPad will be the new record for digital transformation of geometric construction learning in school.

For the same, I started to think about how to provide them computers with internet access. I asked to the school management either there is internet connection in school computers or not. Finally, I found that there is no internet connection in the computers of lab. I asked, *why we were not connecting internet in our school computers even we are teaching computer science as a subject.* School authority replied that, *if we connect internet, the students start to focus on unnecessary extra things rather than their specific content.* I understood the situation of school computer on which my participants won't be used it. I started to think how I can connect the internet for my work in the laboratory. Finally, I explained my action research agenda to the school authority, for the same school provided the permission to connect internet for this purpose. Then it was immediately connected the internet in the computer lab. Now my teaching paradigm for my action research was going to transform in a new dimension. Students requested to use MathsPad themselves highlights a gap in providing sufficient hands-on experience during the first intervention. The findings further resonate with constructivist perspectives, which emphasize that meaningful learning can be supported through social interaction, dialogue, collaboration, and the active construction of knowledge (Bruner, 1996). During the intervention, participants learned not only through teacher guidance but also through peer observation, discussion, and shared reasoning. They voiced that it could address their need to understand concepts better through active engagement. After reflecting on the results obtained during the first cycle, it became apparent that some additional measures were required to cover the learning needs of the participants and ensure the involvement of all students during the second cycle.

Therefore, I modified the existing intervention plan to include more guided activities, collaborative tasks, and proper use of the MathsPad app. At the same time, I discussed with the administration of the school the importance of having a stable internet connection and showed the advantages of using digital technology to increase the engagement of students and improve their knowledge in geometric constructions. These discussions helped to change the attitude of administration to the role of technology from mere complementary tool to an indispensable part of instructional process. This experience is an embodiment of the TPACK approach, in which effective integration of technology into instruction is based on the interrelation between technological, pedagogical, and content knowledge (Mishra & Koehler, 2006).

Figure 20

Teacher's Feedback on Pre-Research Orientation Meeting



"Use of Digital Math Pad Tools for Improving Geometric Construction Proficiency in Grade X Students: An Action Research"

Reflection Writing For My Action Research

Teacher's Name: Keshab prasai Date: 2081/08/13

Level: Secondary Contact No: 9842698858

Subject: Mathematics

1. What strategies do you suggest for integrating digital tools like Math Pad into geometric construction lessons to maximize student engagement? *(Focuses on effective teaching methods.)*

1. First of all students should be aware about the construction of some standard angles like 30°, 15°, 60°, 45° 90°, 75°, 120° etc with the help of compass, protector.
2. Instead of traditional compas drawing teacher should use the digital divices and apps to teach construction.

2. How can I manage classroom dynamics effectively when introducing a new digital tool to ensure all students stay on task? *(Addresses practical classroom challenges.)*

First of all introduce your tools properly. Give chance to use these tools for students too. take enough time in the begining of the use of new technologies. Keep all students silence and give equal priority to all students

3. What potential challenges do you foresee in implementing this action research, and how do you think I can overcome them? *(Helps anticipate and mitigate issues.)*

You are the most labourist and hard working teacher and always ready to implement new technology and method in your teaching. Though students might unfamiliar new tools and techniques, you may handle the situation. Be sure the presence of all students in every day.

In second intervention of one week duration, my participants practiced geometric construction digitally using MathsPad and finally submitted the solution downloading the PDF via mail. In this journey of learning, my participants would have the conceptual knowledge on both geometric construction and ICT integration in mathematics.

Hands-On Digital Practice in the Lab.

Based on the need identification of my participants from the first intervention, finally I entered into the second intervention, where the learners performed construction using MathsPad digital tools. They desired hands-on practice in the lab. In first cycle I leaded visualization with MathsPad and they followed using manual instruments like paper pencil and geometric box. When I made statistical insight on

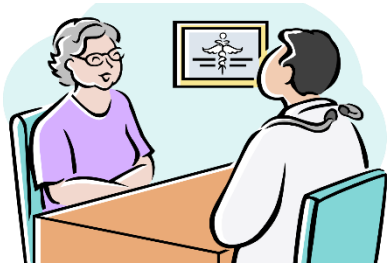
cycle-1, out of 15 marks, the average of pre-Test and post-test score was 6.2 and 10.7 respectively, it shows that the average improvement is 4.5 marks. It fostered the emergence of conceptual clarity, increased engagement and motivation of my participants. In cycle-1, from the first day of teaching student participants enjoyed the classes with active participation. Except in the first three days, most of them were regularly present. Analyzing the gaps found in cycle-1, participants required hands-on practice providing direct access allowed students to actively engage with geometric construction tasks, promoting better understanding through exploration. All the participants desired to use digital platform for their construction other than paper pencil. As suggested (in fig. 20) by a school mathematics teacher during the Pre-Research Orientation Meeting and based on the demand of my participants, I decided to provide such opportunity to the participants to use the digital MathsPad construction tools independently.

Empowerment through Active Participation

The first day of the second intervention took place on Monday, 8 December 2024. All participants were familiar with MathsPad construction tool and ready to carry out laboratory experiments. Focusing on their need, I introduced a story to build the class environment more active. The title given was *"Story of a Fever, Search for a Cure, and Building Mathematical Understanding".* The participants were presented with an image of two people and asked to analyze it critically.

Figure 21

Conversation between Patient and Doctor



In analyzing the picture, some participants were able to conclude that the patient suffers from fever. The doctor is asking her health problem. Different critical arguments raised between the participants observing the picture. Some of them start to analysis with the critical lens. Saanvi reflected that;

> *Just like the doctor needs correct information to treat a patient, in mathematics we must first understand the problem clearly before solving it.*

Prashant compared;

The process of treatment with step-by-step mathematical problem solving, saying that each instruction must be followed carefully just like a prescription.

Saanvi noted that just like in the case of treating a patient, mathematics requires a clear understanding of the problem in order to solve it successfully. Prashant compared curing the disease with step-by-step solving of word problems, everything prescribed needs to be carried out to get the right result. I shared that the picture was of Sita guruma and Dr. sharpa. Having collected participants' ideas, I proceeded to present the main story of Sita guruma and Dr. Sherpa.

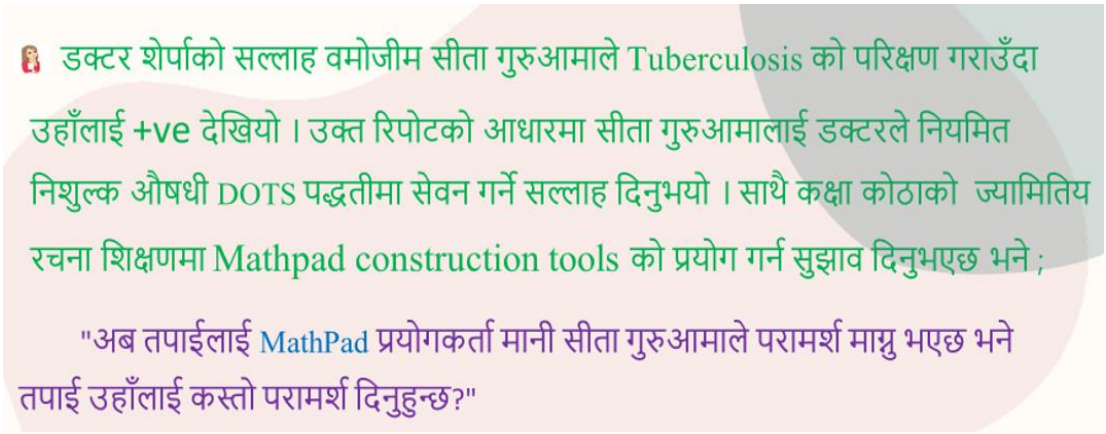
"सीता गुरुआमा कक्षा कोठामा आफ्ना विद्यार्थीहरुलाई ज्यामितिय रचना सिकाइ रहनु भएको वेलामा अचानक खोक्न लाग्नु भयो र उहाँलाई ज्वरोपनि आएको रहेछ ।हप्तादिन सम्म ज्वरोले नछोडेपछि डक्टर – शेर्पाकोमा चेक जाँच गर्न जानुभयो। डक्टर शेर्पाले बिमारका लक्षणहरु सोध्नु भयो। सीता गुरुआमाले आफूलाई खोकि लाग्ने,ज्वरो आउँने, छाती दुख्ने, वान्ता हुने जस्ता लक्षणहरु डक्टरलाई बताउँनु भयो।त्यसपछि डक्टरले सीता गुरुआमालाई उहाँको पेषाको वारेमा प्रश्न गर्नु भयो । सीता गुरुआमाले आफू सामुदायिक विद्यालयकोगणित शिक्षक भएको बताउँनु भयो। यसको आधारमा डक्टर शेर्पाले सीता गुरुआमा लाई सरुवा रोग हुनसक्ने संका गरी Tuberculosis परिक्षण गर्न सल्लाह दिनुभएछ" भने ,

माथि उल्लेखित *context* को आधारमा डक्टर शेर्पाले किन उहाँ लाई *Tuberculosis* को परीक्षण गर्न सुझाउनु भयो होला ?

All my participants shared their reflections with full of excitement, among them one of the reflections was given by Samita.

According to Samita, the question about occupation is significant to the patient. Sita Guruaama acts as a mathematics teacher in a community school where she interacts with many pupils every day. Since tuberculosis is a contagious disease that spreads through air, persons who spend much time in congested classrooms have high chances of contracting this condition. As a result, the doctor viewed the occupation environment as one of the causes of the disease.

Among them, Samita provided an analytical interpretation by explaining that the doctor's inquiry about the patient's profession was significant, as Sita Guruaama, being a mathematics teacher in a crowded classroom environment, may have a higher risk of airborne infection like TB due to frequent close contact with students. After listening the reflection of participants including Samita, I continue the story further to the class.



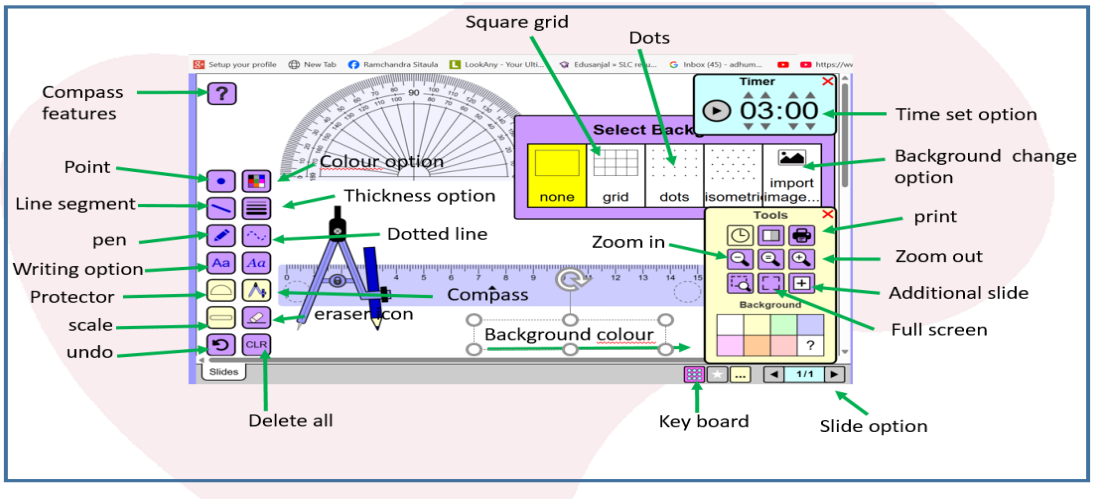
Neha was conscious of the use of MathsPad as an instructional technology. Neha suggested that the teacher could use MathsPad Construction Tools for teaching geometric construction. Neha asserted that with the help of MathsPad, there would be less need for repetition of drawing on the board, less physical strain, saving time, and increasing student involvement during the teaching-learning process.

The understanding of Kritika about MathsPad as a learning technology was deeper than that of Neha. According to her, MathsPad is capable of helping teachers create a better learning environment that is safe and creative. MathsPad, in her opinion, is an instructional technology which supports visualization and involves students actively in mathematical learning.

Based on the students' reflections the storytelling activity increased participants' engagement and curiosity. Instead of directly introducing geometric construction tasks, the story created a meaningful context that attracted students' attention and encouraged active participation. Participants became emotionally connected to the situation and started discussing ideas critically. This made the classroom environment more interactive and learner-centered during the second intervention. After diving to the story and critical thinking, all the students were actively engaged during the second intervention of my action research. Just after the story analysis, they started from the very beginning of the features identification of the MathsPad construction tool.

Figure 22

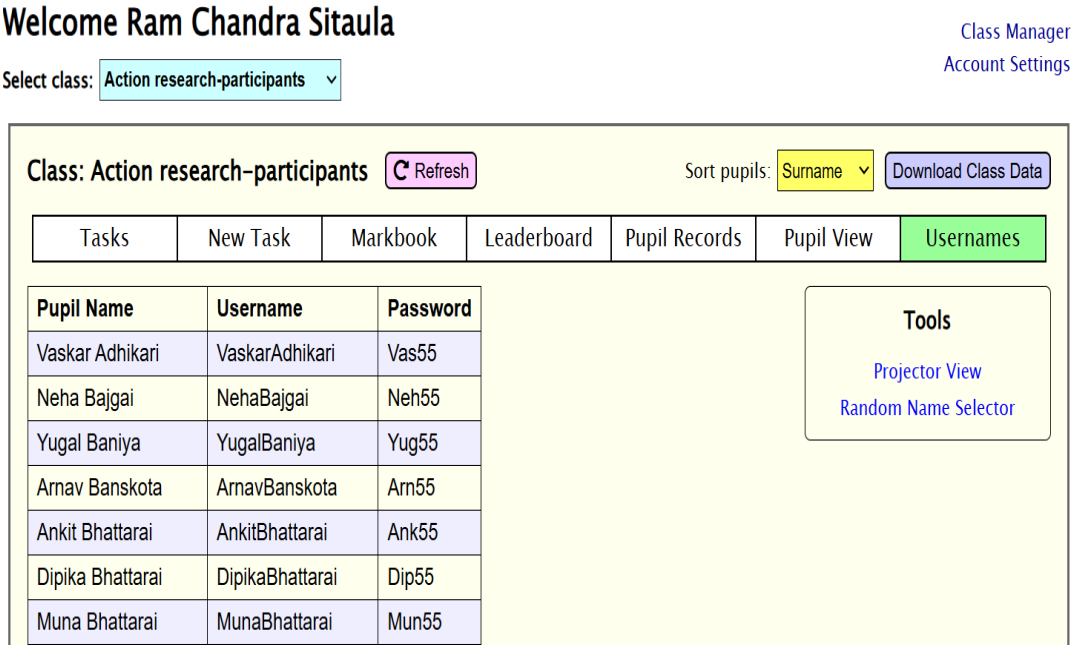
Features on MathsPad Tool



Initially they opened website https://www.mathspad.co.uk/i2/construct.php. Then gradually visited the different features on MathsPad after logged in on their specific username and password as shown in the figures 24. Just after logged in, they started to explore all the features along with their peers. I acted as a scaffolder only for a few needy participants.

Figure 23

Participation Name List During Action Research

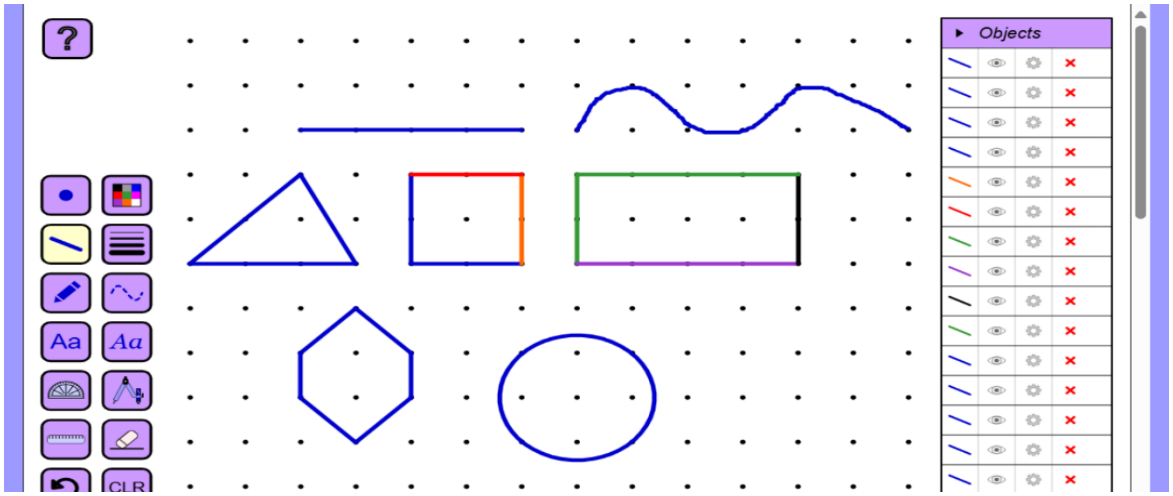


When they identified the features on MathsPad, they played with the different tools. They open that background of dots and started to draw both straight and curve

lines. They drew many shapes like square, triangle, circle, rectangle, hexagon and rhombus.

Figure 24

Shapes Drawn by the Participants Using MathsPad Initially



They practiced to draw lines, angles and also learned to bisect them using compass digitally. It was quite difficult to handle their excitements. When I asked, *"how you doing?"* They answered, *"We are doing with fun. It just like game, easier to construct."* During the activity, students frequently interacted with one another, with one student asking questions to another, and others joining in, creating a lively and enjoyable classroom atmosphere. Some students expressed their excitement by speaking in loud voices, while others laughed together, demonstrating their enjoyment and engagement in the learning process. Even they were asking me additional time for practice while cycle-2, day-1 class time was over. Overall excitement of the first day of second intervention was unbelievable. These observations indicated my research showing that peer interaction, laughter, active participation contribute to student enjoyment and engagement in learning environments. At the end of class Sunami reflected her experiences as below.

She expressed, *"In today's class students were able to do it digitally. It was a golden opportunity for students to learn from digital method."* The voice of Sunami signified that they were feeling glade on having this opportunity. Students felt more engaged, less bored, and more excited in digital classes. She added, *"Not only for the grade 10 students it should be used from primary level for better and good studies."* It was a great suggestion for me. She shared from her entire experiences. Digital

learning was more effective, fun, and motivating than manual methods moving from teacher-centered (first cycle) to student-centered (second cycle). Finally, she shared, *"While doing manually it was very hard to understand the measurement but using MathsPad construction tool it is far better to understand the construction process. By manual process students feel bored in class but in digital way students feel more engaging and their excitement levels are high."* It was the most important truth that the use of MathsPad improved clarity in measurements and built their conceptual understanding via engagement. This shift showed the progress in learning process.

Another participant, Neha, provided a detailed account of her interactions with MathsPad. Neha stated that compared to manually constructing problems, using the digital tools made constructions easier, and even enjoyable. *"MathsPad tools made constructions simple and fun. I felt confident, and I finished the tasks with a greater degree of effectiveness,"* she noted. Additionally, she remarked, *"Digital tools sharpened and clarified the measurements whereas manual instruments made the measurements frustrating."*

Neha also appreciated the collaborative peer support that the digital sessions provided. *"Whenever the tools confused me, I was able to get help, and we learned together. The tools quickened the process, and we were able to resolve our errors right away,"* she stated. Like Sunami, Neha also encouraged that the MathsPad tools be made available in lower grades. *"Digital tools should not be limited to grade 10 students only. If students from primary level get such opportunities, they can learn better and feel more confident in their studies,"* she said.

Sikshya expressed the same feelings when thinking about her experiences while constructing one parallelogram equal in area to another one. She said, *"At first, I felt confused, but when I practiced with the MathsPad tool, my confidence slowly increased. Day by day, I began to feel better and more capable."* She also expressed, *"The MathsPad tools sparked a different kind of energy in me. I felt I could construct with autonomy, and I could help my friends when they got stuck."* In her case, digital practice boosted the initiative she took to help her classmates. This is a positive shift in her sense of responsibility.

The reflections of Neha, Sunami and Sikshya all draw together the same sense of digital practice empowerment. These students noted how engaging with digital learning shifted the experience of boredom, clarified measurement, and most importantly, enhanced confidence. Furthermore, the use of MathsPad technology

transformed the learning space from being primarily teacher-directed to being student-directed. Students took initiative and worked collaboratively to help each other.

Sunami, Neha, and Sikshya's stories really connect with Vygotsky's sociocultural theory. Vygotsky believed learning happens through using different tools and connecting with others (Vygotsky 1978). Here, the MathsPad became that tool. It let students break down tough problems into smaller, easier steps. It became a mediator between the learner and the concept. Students were really working in their ZPD. They were able to complete constructions that previously they found challenging with a little of my guidance and support of their peers. I shifted my role from the primary knowledge holder to a scaffolder who worked more in the background and provided support when required.

This shows that students felt empowered because they took an active role in learning, not just sitting back and listening. Using the MathsPad software, they built new knowledge by exploring on their own and with classmates trying things out, fixing mistakes, and checking their geometric constructions. This matches what Vygotsky described in his Social Constructivist Theory: real learning happens when people interact and work together. The continuous guidance and prompt feedback I provided them also constituted the scaffolding process, whereby the students were able to engage in constructing the geometric shapes that at first seemed difficult for them to do on their own (Anghileri, 2006; Margolis, 2020). In relation to the TPACK framework, the purposeful combination of MathsPad and appropriate pedagogy with geometrical content has led to the creation of a student-centered learning environment. Additionally, the happiness, laughter, peer interaction, and discussion about mathematics concepts displayed by the students indicated increased participation and self-confidence, which were in line with Bandura's Self-Efficacy Theory postulating that effective learning experiences increase confidence in one's abilities (Bandura, 1997). Overall, these results showed a slow transformation from the teacher-led class to the participatory and student-led class for mathematics.

Development of Digital Literacy

As I turned back on my teaching carrier, I started my teaching journey using chalk, duster and blackboard. I followed the same cultural root what I learned in my school life. When I met Mr. Bobmackforsion, then I knew from him about the geometric instrument box which he brought for our school, as I explained in my chapter-I. I touched computer first time in the year 1996 AD, however could not learn

more due to several factors like, lack of interest without knowing the importance of computers, limited computer devices, financial crises etc. Gradually, I tried my best to make my teaching profession comfortable. But waiting for several years, I used Google, Facebook, Twitter, Instagram, YouTube, Gen-AI and many more apps and online tools that sharpen my teaching carrier. I experienced new ideas from YouTube videos about mathematics teaching. As I knew that it was my starting point of digital literacy**.**

Digital learning environments provide a more flexible and stimulating teaching and learning environment that deepens students' understanding of complex concepts, simplifies the teaching process, and nurtures students' engagement in learning (Kshetri et al., 2026). While pursuing my master's degree in mathematics education at Kathmandu University, I developed my digital literacy which helped me to incorporate different digital tools and interactive resources in mathematics teaching, which also improved my teaching and increased students' engagement in the learning process. As I reflect on the more difficult phases of my academic and teaching career, I recall my increased use of technology and of digital resources for personalized, collaborative and data-driven mathematics instruction at the school level. Through the use of technology in teaching mathematics, I could analyze the process of learning among students and consequently tailor my teaching methods, which led to positive results for learners (Muyco, 2025). During the practice involving geometric construction of lines and angles on the MathsPad software, my participants were taught how to construct and bisect lines and angles digitally. They were assigned a task of bisecting a line and angles, and they worked actively.

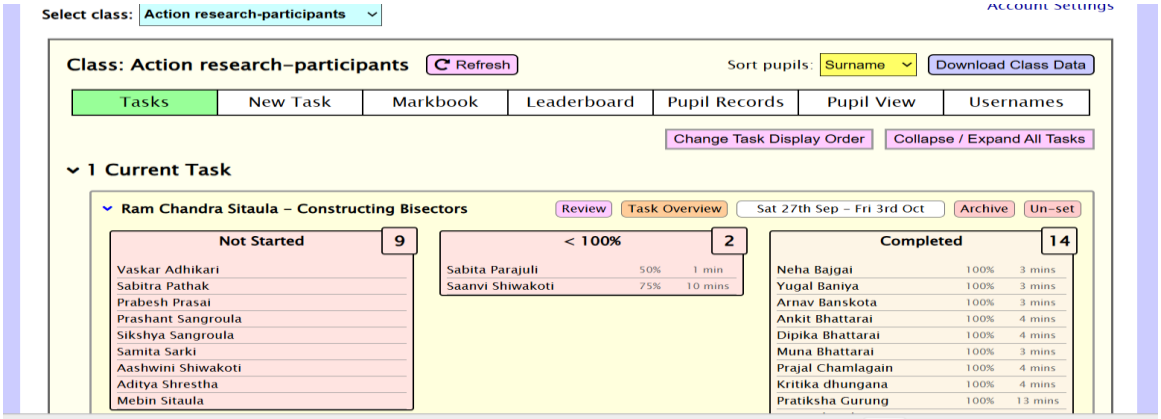
Figure 25

Line Bisection and Angle Bisection Using MathsPad

Digital literacy of my participants was displayed through the practice of the given tasks as well as their submission, as follows. Out of the five given tasks, which comprised two from angles and three from line segments, they executed all as given below. During the process of doing the activity, it was automatically submitted to my class manager account. In carrying out this activity, the students made an attempt to reduce the time used in completing the tasks, meaning that the proficiency of the geometry construction skills was being enhanced through the MathsPad software. A screenshot of the task performance at the moment was given below in figure 26.

Figure 26

A Screenshot of the Task Performance



From above, it was evident that the participants were actively engaged in the exercise. At least, it was seen that 14 participants had already submitted, scoring 100% within 3-4 minutes. However, Pratiksha scored 100% in 13 minutes. On the other hand, Sabitra and Saanvi had not finished. Saanvi attempted to answer question number 3(fig.27) but did not attempt question number 5(fig.27), despite being a brilliant student. This may suggest some sort of difficulty navigating through the technology or even a lack of confidence when attempting certain construction processes. It is through such incomplete attempts that scaffolding becomes crucial in order to develop better habits in terms of technology as well as mathematical skills. Even during the recording of this particular session, it seemed that there were nine participants who did not submit their answers. In one instance, I watched as a participant worked with their peers, which suggests there is some level of digital interaction, even if the confidence or proficiency is not uniform. The confidence level is further supported the use of MathsPad to construct geometric shapes. They seemed to gain confidence in their technological skills.

Improved Confidence and Self-Efficacy

In the current research focusing on geometric construction with Grade X students with the help of MathsPad, another significant point is related to the improvement of the participants' confidence and self-efficacy. Initially, during the second intervention, it was noticed that students were confused regarding the use of the MathsPad software. As more time was spent teaching with the aid of this tool, they became familiar with it. In particular, through interactions within groups, their confidence developed in a way that allowed them to work autonomously and feel satisfied with themselves. Such findings support the theory of self-efficacy presented

by Bandura (1997), whereby successful performance of a specific task leads to greater confidence in performing similar tasks in the future.

Students' Learning Journey from Struggle to Confidence

Ashwini's reflection of Day 6 illustrates distinctly how her level of confidence increased gradually. In the initial statement, she wrote, *"At first it was a struggle to do the task, but after a while we properly constructed the parallelogram with the help of MathsPad construction tools."* This short story of Ashwini makes it clear that all the participants felt fear and uncertainty while using the new digital tools initially. They were not sure about the correct positioning of the digital compass, ruler, and protractor at first. After regular practice, however, they became able to use all the digital tools effectively. This fear turned into a successful event, which is a significant component of *"mastery experience."* This is one of the four sources of self-efficacy, proposed by Bandura.

Later on, after several practices, she wrote, *"It was very easy to use MathsPad construction tools. As this is our first time using this MathsPad construction tool, we were more confident and excited to use it."* In this case, she and her peers felt confident and eager to continue the task because they had used the tool successfully. At this point, she was eager to continue the task because she was no longer afraid to make mistakes. Such development can be clarified by the constructivist learning theory because it asserts that learning happens through direct experiences. Students who did the digital construction realized that they were acquiring knowledge. It is obvious that their confidence grew because they shifted from not understanding to understanding.

Overcoming Nervousness Through Practice

At the end of Day 7, Samita Sarki wrote, *"At first my friends were nervous using MathsPad construction tools, but I was very familiar and had used it before also. It was difficult for using compass at first time... After using MathsPad construction tool, we felt very clear and comfortable doing or using it."* This voice of Samita signified another stage of confidence. Initially, she was nervous due to unfamiliar tools. However, regular interaction in peer or group, the tool becomes familiar and easy to perform geometric construction. Samita's use of the words "clear" and "comfortable" shows the internal shift from anxiety to assurance**.** The students were involved in group work in six different groups where peer support and consistent teacher guidance ensured the creation of an interactive learning

environment. By interacting in discussion, demonstration, and problem-solving, students were able to overcome their fear of geometric construction, thereby becoming more capable of conducting construction operations on their own. The current learning experience is based on Vygotsky's ZPD where students were capable of doing tasks with help from peers and teachers only to become capable of conducting tasks on their own in the end (Vygotsky, 1978). Instructional scaffolding through proper guidance and timely feedback helped the students not only understand concepts but also learn procedures (Anghileri, 2006; Margolis, 2020). Due to repeated success and learning through collaboration and MathsPad, the attitude of students towards learning was changing. Geometry became for them a subject of interaction, discussion, and discovery rather than a subject of difficulties and help from the teacher.

Growing Confidence Motivated to Strengthen Math Skills

> *At first, learning geometric construction was very hard for me and my friends. We had to use a ruler and compass to draw everything by hand, which took a lot of time. Sometimes our constructions were not accurate, and we felt unsure of ourselves. But after learning with MathsPad tools, I felt more confident because I could complete the construction faster and more correctly. Now I believe I can do better with digital tools.*

Saanvi wrote on her reflection on Day-14. Taking reference of her voice Saanvi and her classmates faced challenges initially. They had to use a ruler and compass to draw everything by hand, which took a lot of time. Working for a long time, still their constructions were not accurate, and this made them confused. They often had to wait for their teacher to explain each step, which slowed things down and made them less confident. Teacher had insufficient time to reach to every student. However, once they worked construction using digital MathsPad tools, things began to change. At first, Saanvi felt a little confused about using the digital tools. Working with the peers and team taking help from the teacher, she started to feel more comfortable. She understood that she could complete the constructions faster and more correctly. This success helped her believe more in her own abilities.

According to Bandura's theory of self-efficacy, students build confidence through repeated efforts on tasks and receiving positive feedback (Bandura, 1997). Saanvi learned from her classmates working together on geometric constructions and, as confidence defined their narratives, the constructions and details came clearly and

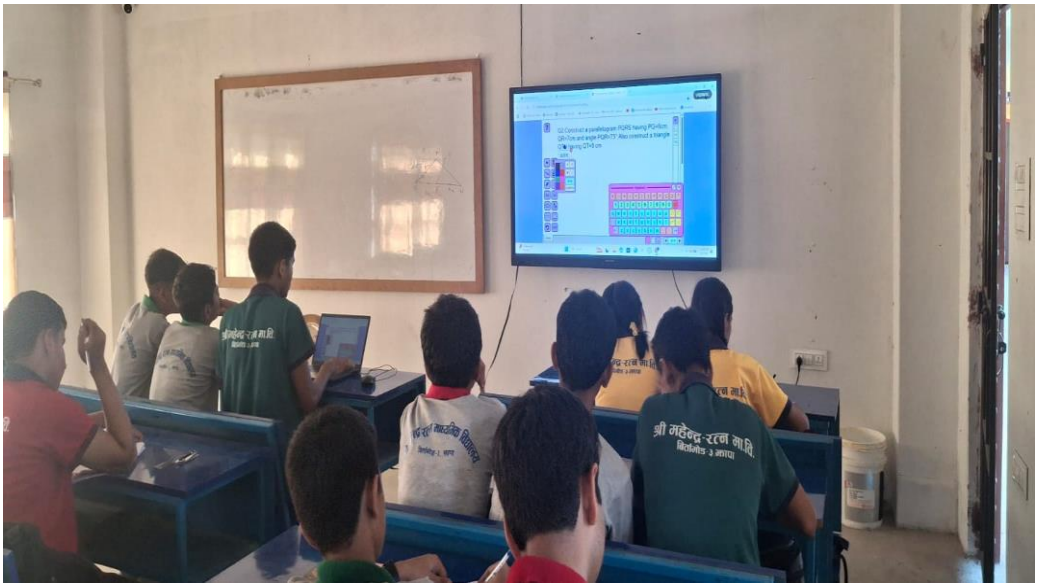
accurately. As a facilitator I employed verbal conversion, as another source of self-efficacy in Bandura's theories. I continually supported them with phrases like, *"You can try again,"* and, *"It's easy once you do it,"* or, *"Look, you already made one side correctly."* As I observed every time students received positive feedback, they felt more convinced and confident Ultimately, students began to assist one another. This kind of sharing and collaborative practice allowed the development of collective efficacy, the conviction that the entire group can achieve and succeed together. I encouraged all my participants to work in a group or peers. Students who grasped the content quickly were able to assist their peers. This kind of social modeling provided weaker students with the assurance of, *"if my friend can do it, I can do it too."* Such vicarious learning is another major source of self-efficacy (Bandura, 1997).

Growth Through Hands-On Experience

Students used to find geometric constructions time-consuming and confusing, especially when they were performed manually with a compass and ruler. Ashwini said that manual methods made students feel *"bored"* in class, but *"engaging and exciting"* digital construction shifted that perception. Progressing through the sessions, the students' behavior began to change in a positive way. In their manual practice students did less interaction in peers then that of digital platform. But by the second intervention of the action research, they started discussions, making comparisons between different constructions and even teaching each other.

Figure 27

Students Performing Geometric Construction Using MathsPad in Group



During the group work one student said to another, *"Let me try, I think I can draw triangle, equivalent to the area of given quadrilateral."* Such statements indicate students were beginning to take ownership of their learning. The students were no longer passive listeners; instead, they were beginning to take greater initiative in their learning. This shift is consistent with Bruner's (1960) spiral curriculum, which emphasizes building new learning on learners' existing knowledge and revisiting concepts at progressively deeper levels of complexity. In this sense, students' prior understanding provided a foundation for engaging with new mathematical concepts and extending their learning. Students worked confidently moving on to more advanced constructions digital tools having successfully worked on a parallelogram. Their confidence was cumulative success bred more success. Both Ashwini, Saanvi and Samita's reflections captured an emotional transition which was distinctly from fear to joy. They used the words *"excited", "clear", "comfortable", and "confident"*. Emotions fuel an essential element of learning and the positive emotions mentioned directly influence enhanced recall and assist the movement of learning in a positive way. The encouraging classroom environment supported students to take risks and learn from their mistakes. Each of these small successes became a building block for an even stronger self-belief.

Chapter Summary

In this chapter, I have presented my experiences as a teacher-researcher and the learning experiences of students while using the MathsPad application for geometric constructions. From my classroom observations and students' reflections, I found that Ashwini, Saanvi, and Samita gradually developed a better understanding of geometric constructions and became more confident in their learning. At the beginning, some students showed hesitation and lacked confidence when performing constructions. However, as they practiced using MathsPad, they became more interested, motivated, and willing to solve problems independently. Their willingness to use MathsPad again showed me that the learning experience had positively influenced their attitudes towards geometry. I also realized that using digital tools, along with proper guidance, encouragement, and opportunities for practice, could help students understand geometric constructions more meaningfully. Their experiences encouraged me to reflect on my own teaching practices and recognize the importance of creating a supportive and participatory classroom environment. Overall, this action research helped me understand that integrating MathsPad into mathematics teaching

can support students' conceptual understanding and confidence while also providing me with valuable opportunities to improve my teaching practices.

CHAPTER V
SUMMARY, FINDINGS, CONCLUSIONS AND IMPLICATION

The current chapter serves as an all-inclusive analysis regarding the summary, key findings, conclusions, and implications of the 15-day action research conducted in the classroom using digital MathsPad technology to enhance Grade X students' skills in constructing geometry figures. This chapter is a consolidation of the whole research process, from the identification of the classroom problem to its implementation and reflection within a practical setting. In this case, I have shown how initially the students found it challenging to understand geometric construction because of abstraction, poor visualization ability, and a teacher-centered approach to teaching. In order to address this problem, I have performed structured MathsPad activities in the "Construction" chapter of CDC Grade 10, covering the following topics: perpendicular bisector, angle construction, triangle construction, and polygon construction. From these lessons, I was able to see the impact of MathsPad activities on the way students learn geometry. As seen from the title of this chapter, it shows my experiences of acting as a teacher-researcher. It involves planning, implementing, observing, and refining teaching practice through conducting several cycles of action research. In the following paragraphs, I will highlight the main issues that have been raised by students' feedback, classroom observations, and reflection on actions performed during teaching practice. Finally, the last section describes the findings and practical implications of the present study.

Retrospection as a Researcher

As a teacher-researcher, I initiated my research with my practice, my class, my students and my concern. That is students' difficulty in geometric construction. Action research is not merely a requirement for my academic course. It is an opportunity for reflection, introspection, and fulfillment of my responsibilities as a mathematics teacher at the public secondary school. Purpose came out of what I experienced and observed in my classroom. I tried my best to help students of Grade X learn geometric construction with the help of compass and ruler. However, I realized that not all students were able to follow my lesson. Their performance looked nothing but copy of mine and they even questioned me saying Sir, why do we learn construction in our

class? Is this going to help us in SEE? Such inquiries led me to reflect on my practices as a teacher and the problem situations in the class raised certain questions.

- Why do students consider geometry construction as difficult and boring?
- Why can't they visualize and design construction?
- How can technology be utilized in a constructive way to enhance comprehension rather than demonstration?
- And most importantly, how can students be actively engaged in constructing geometric knowledge?

In the meantime, I recalled myself a learner during my tenure at Kathmandu University where a learner-centered approach and visualization of learning were highly appreciated. The idea encouraged me to adopt innovative practices. In doing so, I planned to use MathsPad application to enhance my students' geometric construction skills. Throughout the process, I had been observing my students' behavior, interaction and learning processes meticulously. Initially, some students felt shy and unfamiliar with digitalized technology. But gradually they developed a sense of curiosity, confidence and participation in the class. They used to debate on construction procedure, correct their errors and assist other students. The atmosphere of the class changed from passive to active. On many occasions, students used to show eagerness to attend mathematics class and ask me, *"Sir, will we use MathsPad again today?"* Such enthusiastic attitude towards learning is reminiscent of what my mentors had once said, *"What we experience for the first time tends to be the most valuable."* While doing internship in the latter half of my course work period, I shared my experiences gained from action research with 24 secondary level mathematics teachers in the session titled, "Interactive Visual Manipulatives Using MathsPad for Geometric Constructions".

Throughout my research process, some students faced challenges due to lack of technological skills while some struggled in getting instant results for accurate construction. Collaborative work was equally challenging as they proceeded at varying speeds. The above-mentioned challenges turned out to be great learning opportunities for me as well as students in their journal entries. My role as a teacher-researcher included data collection through observations, reflections, and interview with students. Data analysis included identifying trends concerning engagement, visualization, confidence and comprehension, etc. Periodic interaction with my

dissertation advisor ensured credibility and validity of the interpretations. Overall, action research taught me how crucial it is to start by introspecting one's practice. In my study, the involvement of students played a significant role. Students were actively involved in the process of constructing mathematical knowledge in order to be proficient in mathematics which is highly required by the society. Looking back, I feel that action research turned into a transformative experience. It gave me an understanding of the importance of action research to promote professional development and improve classroom situation. Above all, action research taught me to walk any road with my students for observation and learning.

Visualization of My Research Plan

I came up with the research idea based on my personal experience and reflection of my own practices in teaching mathematics. Initially, being a beginner in my professional life and straight after obtaining B.Sc. degree, I began teaching mathematics for basic and secondary classes while simultaneously engaging myself in further education. As a beginner, I applied traditional methods of teaching such as lectures and demonstrations of constructions by using common drawing equipment. As time passed, it turned out that the teacher-focused approach used in teaching paid more attention to curriculum coverage than students' conceptual understanding and enhancing visualize abilities. The students had problems constructing shapes, made mistakes repeatedly, and showed low level of confidence when working in the class. It is worth noting that poor academic achievements among students in constructing topics were noticed. Thus, the need for visualization in learning geometric construction became clear, and traditional approach was unable to provide it.

Thus, I found that action research was the best option for conducting research on my classroom practice of teaching geometric constructions using MathsPad. In preparation for the intervention, I conducted extensive review of the relevant theories and studies, which made me familiar with ways in which digital technologies could assist learning. Having learned how to help students learn with the help of digital technology, I formed an image of my research as a cyclic process of diagnosing students’ learning problems, developing interventions in the class, implementing interventions, observing students’ reactions, and analyzing results of the observations in order to make improvements to the next lessons. I did not expect any changes to occur immediately since I considered students’ learning as a step-by-step process of practice and teacher assistance, collaboration among peers and application of

MathsPad. With the help of this image, I improved the second cycle of action research according to my reflections on the results of the first cycle. While conducting this research, I viewed it not only as an investigation of the problem but also as a tool for improving my professional practice through reflection.

Research Question Formulation

The initial research question was formulated based on classroom observations and the analysis of the reasons behind the observed difficulties students faced while constructing figures. The main problem was that students were minimally involved in construction and found it difficult to follow the procedural rules of geometric constructions. Most students lacked interest, and even simple tasks caused confusion among students, making them commit mistakes while doing constructions. Such observations motivated me to change my teaching approach and formulate the following questions: Why is it so difficult for students to visualize the geometric construction process? Why are students more prone to imitations than understanding?

Even though related literature and other theses helped to form my research topic, the importance of digital means in addressing students' problems became obvious. The selection of a suitable action-research question seemed challenging. However, by discussing my ideas with the supervisor and other teachers, I managed to formulate two questions that meet the requirements of my work: How can the application of digital MathsPad construction tools affect the geometric construction skill of Grade X students? In addition, what role can digital MathsPad construction tools play in developing students' conceptual understanding and interest in geometric construction?

Research Paradigm in the Study

The research was done in an ordinary mathematics classroom where I happen to be the teacher. Students usually have problems when trying to perform geometric constructions. From my professional experience and participation in various academic conferences, I know that teaching processes are not performed independently but rather under some general theories regarding knowledge. Interaction with a variety of paradigms, including positivism, post-positivism, interpretivism, and the critical, has helped me understand that the work of each researcher is underlined by specific belief system. According to Creswell (2015), all the researchers have some beliefs that define their actions.

The primary factor influencing my decision to select an interpretivist paradigm is the possibility to find out what Grade X students felt about using the app for their geometric construction tasks. In addition to quantifiable results such as test scores, I was interested in investigating the perceptions of the learners, interaction in the classroom, their increased confidence, engagement, and improvement in conceptual understanding during the intervention process. In addition to the interpretivist paradigm, I used a critical approach to conducting my study. The use of this approach allowed me to focus on self-reflection and improvement of my teaching practice in the light of action research process. During the first intervention cycle, I conducted self-reflections to assess my practices, find out potential barriers to effective learning, and develop the ways to improve my instruction. All these considerations played a crucial role in developing the action plan for the second intervention cycle. Therefore, the critical approach does not represent another research paradigm in this case but is combined with the interpretivist one.

Redefining Theoretical Foundations

Two main theories that served as theoretical anchors for the study included the ideas about constructivist learning (students construct their understanding) and collaborative learning. Both of them played a fundamental role in the entire research study as well as its interpretation of students' learning experiences. Indeed, they show what kind of processes take place while students develop understanding of mathematical notions through active participation in the activity, visualization of concepts, peer interaction, and reflection. The current study is based on the theory and focuses on realization of meaningful learning for students who use digital tools of MathsPad technology to learn geometry and perform geometric constructions.

My previous instructional practice was strongly influenced by a technical and instrumental view of knowledge, in which knowledge was primarily understood in terms of its practical application and control (Habermas, 1972). Consequently, in mathematics instruction, I tended to emphasize procedural skills and accuracy, repetition of procedures, and precision in carrying out mathematical tasks. This approach was also consistent with key principles of behaviorism, particularly the emphasis on observable behavior, reinforcement, and the shaping of desired responses (Skinner, 1976). Therefore, in accordance with this paradigm, there was no place for digital technologies and innovative techniques in my instruction as they did not presuppose any reflection on the procedure itself but only its performance.

The present research made me adopt constructivist theories according to which learning becomes the process of creating personal meanings accomplished through conducting research. The use of MathsPad technology allowed students to visualize each step of the construction, make changes in figures, correct mistakes independently, and integrate new knowledge with previous notions. This approach is consistent with constructivist theory about mathematics learning as it shows that students construct new mathematical concepts and create their understanding of the studied subject matter. Intervention helped students move away from passive copying towards constructing meaning and understanding notions like bisectors, angles, and congruence.

The project was also informed by principles of experiential and collaborative learning. Dewey (1902) emphasized the importance of learners' experiences in education and argued that subject matter becomes meaningful when it is connected with the learner's existing experiences and activities. In the present study, students were provided with opportunities to learn through active engagement with geometric-construction tasks, interaction with peers, and hands-on use of MathsPad. Thus, engaging in collaborative activity, learners had enough opportunities to discuss approaches to solving mathematical problems using the capabilities of MathsPad. Working collaboratively, they cooperated with one another to solve mathematical problems and find solutions to them collectively. Generally, the research has changed my perception of students and their attitudes toward mathematics as a discipline. Now, I am sure that students do not have problems with mathematical subjects; the reason for those difficulties is that the traditional way of teaching mathematics fails to establish connection between concepts and reality. In this regard, students' perception of mathematics as a hard and isolated area of knowledge has changed to more positive views about its meaningfulness and comprehensibility. Thus, it can be stated that this action research has proved effectiveness of cooperative learning in the field of geometrical construction.

Reflecting Theoretical Referents

One of the most distinctive features of action research conducted by me is making sure that all theoretical frameworks do not only have implications concerning improvement in test-taking skills but are also expressed in the stories, actions, and thoughts of students. By integrating MathsPad into the process, I was able to provide

approaches to learning that followed constructivist, social constructivist, cognitive, motivational, and TPACK-based learning theories.

Constructivist Learning Theory and Concept Ownership

According to Constructivist Learning Theory, people actively construct their knowledge rather than passively receive it. Indeed, the reflections of students prove that it is true. Those respondents who were used to conceptualizing knowledge through the process of memorization were able to understand why particular steps needed to be performed while using MathsPad. For example, Saanvi, who was one of the more active participants, said that "geometric construction suddenly felt easy and achievable". As can be seen, the student began to view knowledge as something to be actively constructed rather than merely imitated. This finding is consistent with Constructivist Learning Theory, which posits that learners construct knowledge through active engagement with ideas, experiences, and their environment. Neha, being a slow learner, also expressed her thoughts in the following way: "*Everything suddenly clicked*". Her reflections prove that interaction with MathsPad helped her reevaluate her previous perceptions and reconstructed concepts, which is the core idea of constructivism.

Interaction, dialogue, and shared knowledge are the major elements of social constructivist theory, which Vygotsky suggested. In the current study, MathsPad was a platform for interaction between students. Prashant, a boy, who was quite disengaged in learning and lacked confidence in mathematical procedures, said that "*such kind of teaching learning approach not only enriched my knowledge but my social qualities as well*". Indeed, his reflection proves that learning takes place in a social and interactive manner. During instructions, students could discuss construction methods, identify errors in each other's work, and pose questions to investigate the task. All these actions show that people actively participated in the learning process and took responsibilities on themselves, as Vygotsky suggests.

Moreover, Samita shared her thoughts about the interaction between herself and MathsPad, emphasizing that "*the problem that was a headache for me became much easier*". Therefore, we see that the use of technology helped make the process of learning more attractive for learners. All in all, in the current study, MathsPad was used to promote learning in a public-school setting where students were usually afraid of asking any questions.

Zone of Proximal Development and Scaffolding

One of the major outcomes of the current research has been the use of MathsPad as a scaffolding tool. A number of students, who were previously experiencing problems with the measurement or division of line segment into two equal parts, succeeded in achieving the desired goals after a computer-based demonstration using MathsPad. Prajwal commented that "*I am very confident in my construction skill ability because it allows visualization of concepts*." This result is consistent with the idea that learning takes place when a student operates within his/her zone of proximal development, the zone where he/she can accomplish certain tasks with appropriate assistance. Step-by-step instructions made possible through the utilization of MathsPad can be considered temporary scaffolding. Indeed, the aforementioned observation confirms Vygotsky's claimed that learning should take place in conditions when scaffolding creates links between actual competence of learners and potential development. In particular, MathsPad addressed the problem of missing geometry equipment required to complete geometric exercises.

Cognitive Theory of Multimedia Learning and Visualization

According to the cognitive theory of multimedia learning, the performance level of learners increases as long as they face visual and verbal representations. The importance of visualization in the process of comprehending geometry concepts has been mentioned several times. For instance, Ashwini, who had some health-related difficulties with class attendance, noted that "*With these types of technologies I could easily access new ideas even if I'm not able to attend the class.*" Thus, the usage of MathsPad provided students with opportunities to comprehend information more effectively and create mental models based on visual representations.

Learning Through Visual Representations

Visualization of loci, line bisectors, and angles helped to eliminate previous problems. The repeated phrases like "it is crystal clear now" point at reduced cognitive load and creation of more accurate mental models. Motivation, Confidence, and Affective Transformation

Beyond purely cognitive goals, the use of MathsPad resulted in significant transformations related to affective learning objectives like motivation and confidence. Thus, many learners admitted having greater motivation and enjoyment as regards the study of geometry and mathematics. These observations refer to such important educational theories as motivation and intrinsic motivation. In everyday

practice, the statement that "this form of education must be adopted in all places" contradicts with the idea of political critique of traditional lecture-based classes. Neha, who used to oppose teaching of mathematics, declared, "*This type of software needs to be available to every student.*" In general, such observations reflect the idea of intrinsic motivation created through autonomy, interests, and feedback. Generally speaking, the aforementioned theoretical considerations are related to the issue of TPACK.

Reflection as a Teacher-Researcher

The findings indicate a transformation in the pedagogical approach, consistent with the principles of the TPACK framework. The use of the instructors' knowledge of geometry construction along with pedagogical practices such as scaffolding, discussions, and MathsPad was used effectively. This is evident since students perceive changes in pedagogy. For instance, a student asked, *"Sir, why are you teaching us like this? The classes we used to take in school were different,"* and in response, I responded “Sure! I aimed to teach like the same way”. This shows that they have noticed changes in pedagogical practice, indicating the adoption of technology as a teaching device. Through action research, there was reflection, adjustment, and development in pedagogy, thus making up for instructional practices made within the TPACK framework. The voices of all participants together confirm the theoretical basis of the study. Concept learning is influenced by constructivist learning theory, collaboration is informed by social constructivism, guided instruction leads to success from the ZPD, visualization is enabled by multimedia learning, attitudinal change is brought about by motivation theory, and pedagogical transformation is brought about by the TPACK theory. Therefore, from this action research, it is seen how theoretical constructs are manifested in the experiences of learners and therefore the application of the MathsPad device in cognition and geometry instruction in Nepal.

Throughout this action research, I learned that teaching geometric constructions is not simply about explaining steps and asking students to follow them; it is also about understanding their difficulties, listening to their concerns, and finding ways to make learning more meaningful. Initially, I believed that introducing the MathsPad application would help students perform geometric constructions more easily. However, my classroom experiences taught me that technology alone cannot guarantee meaningful learning. Students need proper guidance, encouragement,

opportunities to explore, and time to develop their understanding. I also realized the importance of revisiting basic geometric concepts when students struggle with foundational knowledge, even at the secondary level. Listening to students' requests and observing their learning processes encouraged me to become more flexible and responsive in my teaching. Rather than relying only on my own explanations, I began to value students' participation, questions, peer interactions, and reflections as important parts of the learning process. This research also helped me recognize that reflecting on my classroom practices and identifying my own limitations are essential aspects of professional growth. Most importantly, I came to understand that my role as a mathematics teacher is not merely to deliver mathematical knowledge but also to create a supportive learning environment where students can explore, make mistakes, ask questions, and gradually develop confidence in their abilities. This experience has strengthened my commitment to becoming a more reflective, student-centered, and innovative mathematics teacher.

Challenges in Implementation

There are various challenges in integrating technology tools especially MathsPad software in teaching geometric construction. These challenges include lack of tools, too much demands on teachers' ICT skills, and different interest levels in teachers. While some schools may lack internet connectivity and infrastructure, others may face similar issues in village settings. The one-hour geometry class for collaborative work may also prove insufficient. Despite the provision of ICT equipment by the Government of Nepal, such as computers, internet, and printing machines, lack of electricity and skilled individuals to operate the equipment makes implementation difficult. In my opinion, a lack of interest from teachers to adopt technology tools such as MathsPad despite awareness of their benefits is among the major barriers. Instructors must show intrinsic motivation to incorporate digital tools in the classroom to improve their instructional approaches. Other important barriers include a lack of infrastructure, electricity, and skilled personnel. Nonetheless, the use of technology tends to motivate students to participate actively in classroom learning activities. Hence, technology can support more systematic learning processes and enhance students' conceptual understanding. However, teachers' reluctance to move away from traditional instructional practices and their uncertainty about the educational benefits of ICT may hinder the effective integration of technology into classroom teaching (Knezek & Christensen, 2016). Despite these challenges, the

integration of MathsPad into geometric-construction activities can provide meaningful benefits for both students and teachers by supporting active engagement, visualization, exploration, and the development of geometric-construction skills.

Conclusions

In conclusion, the use of digital MathsPad software for mathematics instruction facilitated better understanding of geometric construction. This action research highlighted real issues such as lack of students' interest, poor visualization, and ability to complete tasks without proper understanding. It shows that MathsPad software allows easy visualization of tasks in a step-by-step way, repetition and revision, correction, and involvement in iterative process to enhance students' knowledge and skills in geometric constructions. The research also found out new ways of motivating and engaging students. Moreover, it helped to improve general teaching practices. As opposed to before where teaching geometric constructions based on traditional examples could make students passive listener, but the use of MathsPad made them more curious and active in learning. Students' anxiety about geometric constructions reduced and became more confident while carrying out procedures. The use of interactive features helped students do constructions either alone or collaboratively with peers. Therefore, doing geometric constructions ceased to involve just rote learning. Conducting this action research helped me reflect on my practice as well as learners' needs. As the results showed, all students are capable of learning mathematics given the right environment. If there is alignment of instructional approaches and needs of students, then the teaching process becomes easier and interesting. Though the planning is complex, I came to realize how powerful technology is in making instruction learner-centered.

Implications of the Study

This action research is intended to improve teaching practices through the use of digital MathsPad software. The findings have certain implications both for my teaching practice as a mathematics teacher and for further research on technology-integration. In my case, the results have implications on current practices, especially through encouragement to use student-centered, visual, and interactive practices. It also helped me better understand the perspectives and needs of students. Thus, I was able to adjust my teaching to meet the needs of learners accordingly. The findings may be relevant for other mathematics teachers in similar settings to facilitate students' ability to visualize and perform geometric constructions without anxiety.

Even though the results may vary depending on the level of students as well as the availability of technological equipment, the suggested approach to learning geometric constructions can be adopted in the classroom. Secondly, this research may act as a guide for other practitioners as well as teachers carrying out action research on the integration of technologies in mathematics teaching and learning. Action research usually involves the identification of problems, implementation of certain measures to address those problems, and assessment of the result. A number of specific products have resulted from this study, such as: MathsPad-based lesson plans revised; action research intervention cycle 1 and cycle 2 conducted; students' geometric construction sample work; reflective journals; classroom observations; interviews; photos/video recordings of classroom activities; and themes identified regarding students' conceptual understanding, engagement, confidence, and geometric construction skill development. In addition to that, this study has shown ways to deal with problems of student indifference towards mathematics learning and lack of visualization skills in performing geometric constructions.

Limitations

Every learning process has some contextual, participant, temporal, and resource limitations. This action research is also bound to have some limitations regarding the use of digital tools via MathsPad. To start with, the action research took place within 15 days only, which enabled researchers to conduct two action research cycles and did not give much scope for additional development and observations of students' learning processes. Secondly, although all 30 Grade X students took part in the classroom intervention, only six purposefully chosen 6 key participants were involved in the in-depth qualitative analysis of the research due to the limited amount of time for the interviews and observations. Finally, the research was conducted within a Grade X classroom of one public school in Jhapa District, which means that its findings cannot be generalized to all schools. Still, there are some implications of the study for classroom teaching. The sample used was small, which limits generalization. Time is another limitation because the use of technology in teaching geometric construction takes more time compared to conventional approaches since students need more time for investigation, improvement, and discussion. Time constraint may become more evident in the setting of Nepal where it is necessary to finish curricular content in a specified period. Another limitation is concerned with digital competence and the speed of learning among students. Most learners benefited

from visualization and interactivity, while others required more assistance to learn digital technologies. Students brought different levels of confidence and understanding to the table, and that really affected their progress. Some didn't make as much headway, probably because they just didn't get enough practice. The study focused more on helping students grasp the big ideas than on teaching them how to lay everything out step by step on paper. So even though a lot of them got a good handle on the concepts and could talk through them in class, a few still struggled to show that understanding in their written work.

Future Directions

Action research has proved to be a great asset for professional development in my career path as a mathematics teacher. It has helped me identify students' behavior in a number of aspects ranging from visualization of the task, interaction, cooperation with peers, and confidence in geometry. Several positive changes observed during the research made me integrate more technology, especially MathsPad into teaching. For the future, I want to enrich my practice by combining visualization and procedural skills through using digital tools and respective written procedure representations. This action research also points to several possible directions for further research. One may be interested in examining the long-term impact of MathsPad use on test scores. Another avenue for exploration may lie in comparing this approach to others through empirical studies. Further, geometric concepts other than triangle constructions may also be studied using MathsPad.

REFERENCES

Acharya, M. R. (2025). Effectiveness of GeoGebra in learning matrices. *Butwal Campus Journal, 8*(1), 187–192. https://doi.org/10.3126/bcj.v8i1.85566

Ali, S., Khan, M., & Rehman, A. (2024). ICT-based learning environments and student engagement in secondary mathematics classrooms. *Journal of Educational Technology and Learning, 18*(2), 55–70.

Anghileri, J. (2006). Scaffolding practices that enhance mathematics learning. *Journal of Mathematics Teacher Education, 9*(1), 33–52. https://doi.org/10.1007/s10857-006-9005-9

Anthony, G. (1996). Active learning in a constructivist framework. *Educational Studies in Mathematics, 31*(4), 349–369. https://doi.org/10.1007/BF00369153

Aphrodite, M. A., & Rita, P. (2021). Young students' ability on understanding and constructing geometric proofs. *Social Education Research*, 121-133.

Awaji, B. M., Khalil, I., & Al-Zahrani, A. (2025). A bibliometrics study of two decades of GeoGebra research in mathematics education. *Journal of Educational and Social Research, 15*(1). https://doi.org/10.36941/jesr-2025-0011

Bandura, A. (1997). *Self-efficacy: The exercise of control*. W. H. Freeman.

Bhandari, S., & Koirala, P. (2025). Digital tools and student motivation in mathematics learning: A classroom-based study. *Nepal Journal of Mathematics Education, 10*(1), 33–48.

Bruner, J. S. (1960). *The process of education*. Harvard University Press.

Bruner, J. S. (1996). *The culture of education*. Harvard University Press.

Chavula, J., & Nkhata, B. (2019). An investigation into the strategies used to teach geometric constructions in secondary schools: A case of a secondary school in Lusaka district. *Zambia Journal of Teacher Professional Growth (ZJTPG), 5*(1), 1-19.

Creswell, J. W., & Poth, C. N. (2018). *Qualitative inquiry and research design: Choosing among five approaches* (4th ed.). SAGE Publications.

Dahal, N., Pant, B. P., Shrestha, I. M., & Manandhar, N. K. (2022). Use of GeoGebra in teaching and learning geometric transformation in school mathematics.

International Journal of Interactive Mobile Technologies, 16(8), 65–78. https://doi.org/10.3991/ijim.v16i08.29575

Danesi, M. (2016). *Learning and teaching mathematics in the global village: Math education in the digital age*. Springer. https://doi.org/10.1007/978-3-319-32280-3

Dewey, J. (1902). *The child and the curriculum*. University of Chicago Press.

Doerr, H. M., et al. (2021). Collaborative learning in mathematics classrooms: Can teachers understand progress of concurrent collaborating groups?. *Computers & Education, 173*.

Drijvers, P., & Sinclair, N. (2024). The role of digital technologies in mathematics education: Purposes and perspectives. *ZDM–Mathematics Education, 56*, 239–248. https://doi.org/10.1007/s11858-023-01535-x

Freire, P. (1970). *Pedagogy of the oppressed* (M. B. Ramos, Trans.). Herder and Herder.

Günster, S. M., & Weigand, H.-G. (2020). Designing digital technology tasks for the development of functional thinking. *ZDM–Mathematics Education, 52*, 1259–1274. https://doi.org/10.1007/s11858-020-01179-1

Gurmua, F., Tugea, C., & Hunde, A. B. (2024). Effects of GeoGebra-assisted instructional methods on students' conceptual understanding of geometry. *Cogent Education, 11*(1), 2379745. https://doi.org/10.1080/2331186X.2024.2379745

Habermas, J. (1972). *Knowledge and human interests* (J. J. Shapiro, Trans.). Beacon Press.

Hoyles, C., & Noss, R. (2008). Next steps in implementing Kaput's research programme. *Educational Studies in Mathematics, 68*(2), 85–97. https://doi.org/10.1007/s10649-007-9102-4

Jonassen, D. H. (1999). *Computers as mindtools for schools: Engaging critical thinking* (2nd ed.). Prentice Hall.

Kemmis, S. (2009). Action research as a practice-based practice. *Educational Action Research, 17*(3), 463–474. https://doi.org/10.1080/09650790903093284

Kharel, S. (2017). Consequences of educational decentralization in Nepal. *Tribhuvan University Journal, 31*(1–2), 89–106. https://doi.org/10.3126/tuj.v31i1-2.25334

Knezek, G., & Christensen, R. (2016). Extending the will, skill, tool model of technology integration: Adding pedagogy as a new model construct. *Journal of Computing in Higher Education, 28*(3), 307–325. https://doi.org/10.1007/s12528-016-9120-2

Koirala, S., & Bhatta, D. (2023). Teacher facilitation in ICT-integrated mathematics classrooms: A study of secondary education. *Journal of Education and Practice, 14*(5), 88–101.

Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development*. Prentice Hall.

Kshetri, P. B., Shrestha, I. M., & Dahal, N. (2026). Dynamic visualization and conceptual understanding of circle theorems through teacher-mediated GeoGebra use: An Action research in a Grade 10 classroom in Nepal. *Advances in Mobile Learning Educational Research, 6*(2), 1904–1928. https://doi.org/10.25082/AMLER.2026.02.005

Kuhn, T. S. (1962). *The structure of scientific revolutions*. University of Chicago Press.

Kumar, P., Yadav, R., & Joshi, S. (2023). Effects of digital geometry tools on students' spatial reasoning in secondary mathematics. *International Journal of Mathematics Education, 12*(3), 45–60.

Li, R., Cao, Y., Tang, H., & Kaiser, G. (2024). Teachers' scaffolding behavior and visual perception during cooperative learning. *International Journal of Science and Mathematics Education, 22*(2), 333–352. https://doi.org/10.1007/s10763-023-10379-6

Li, Y., & Wang, H. (2024). Dynamic geometry environments and students' cognitive development in secondary mathematics. *Journal of Mathematics Education Research, 16*(2), 77–93.

Margolis, A. A. (2020). Zone of proximal development, scaffolding and teaching practice. *Cultural-Historical Psychology, 16*(3). https://doi.org/10.17759/chp.2020160303

Merriam, S. B., & Tisdell, E. J. (2016). *Qualitative research: A guide to design and implementation* (4th ed.). Jossey-Bass.

Mertler, C. A. (2020). *Action research: Improving schools and empowering educators* (6th ed.). SAGE Publications.

Ministry of Education, Science and Technology (MoEST). (2022). *School education sector plan 2022/23–2031/32*. Government of Nepal.

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record, 108*(6), 1017–1054. https://doi.org/10.1111/j.1467-9620.2006.00684.x

Muyco, D. (2025). The influence of technology integration on the academic performance of upper primary education learners in mathematics. *International Journal of Social Sciences and English Literature*. https://doi.org/10.55220/2576683x.v9.394

Olive, J., Makar, K., Hoyos, V., Kor, L. K., Kosheleva, O., & Sträßer, R. (2010). Mathematical knowledge and practices resulting from access to digital technologies. In C. Hoyles & J.-B. Lagrange (Eds.), *Mathematics education and technology: Rethinking the terrain: The 17th ICMI study* (pp. 133–177). Springer. https://doi.org/10.1007/978-1-4419-0146-0_8

Piaget, J. (1972). *The psychology of the child*. Basic Books.

Ramzan, M., Ahmed, F., & Iqbal, N. (2023). Impact of interactive technologies on student engagement and collaborative learning in mathematics. *International Journal of STEM Education Research, 7*(3), 112–126.

Rana, K., Greenwood, J., & Henderson, R. (2021). Teachers' experiences of ICT training in Nepal: How teachers in rural primary schools learn and make progress in their ability to use ICT in classrooms. *Technology, Pedagogy and Education, 31*(3), 275–291. https://doi.org/10.1080/1475939X.2021.2014947

Sagor, R. (2000). *Guiding school improvement with action research*. Association for Supervision and Curriculum Development.

Saleem, A., Kausar, H., & Deeba, F. (2021). Social constructivism: A new paradigm in teaching and learning environment. *Perennial Journal of History, 2*(2), 403–421. https://doi.org/10.52700/pjh.v2i2.86

Sam-Kayode, C. O. (2025). Mathematics teachers' perceptions of difficulties encountered by students in geometric constructions in Egbeda Local Government Area, Oyo State, Nigeria. *Journal of Digital Learning and Distance Education, 3*(9), 1262–1270. https://doi.org/10.56778/jdlde.v3i9.434

Schnotz, W., Ludewig, U., Ullrich, M., Horz, H., McElvany, N., & Baumert, J. (2014). Strategy shifts during learning from texts and pictures. *Journal of Educational Psychology, 106*(4), 974–989. https://doi.org/10.1037/a0037054

Shabani, K. (2016). Applications of Vygotsky's sociocultural approach for teachers' professional development. *Cogent Education, 3*(1), 1252177.

Sharma, P., Adhikari, R., & Thapa, S. (2025). Pedagogical strategies for effective ICT integration in mathematics teaching. *Nepal Journal of Curriculum and Instruction, 12*(1), 41–58.

Sharma, R. (2024). Reducing mathematics anxiety through ICT-integrated instruction in secondary schools. *Asian Journal of Educational Research, 9*(4), 88–102.

Shrestha, A. (2025). ICT integration and student achievement in secondary school mathematics. *Nepal Journal of Education and Research, 15*(1), 78–92.

Shrestha, P., & Adhikari, R. (2025). ICT-supported geometry learning and higher-order thinking skills in secondary schools. *Nepal Journal of Educational Studies, 11*(1), 50–66.

Singh, R., & Sharma, M. (2024). Interactive learning environments and geometry achievement: A study using digital tools. *Journal of Educational Technology in Mathematics, 9*(2), 101–118.

Skemp, R. R. (1976). Relational understanding and instrumental understanding. *Mathematics Teaching, 77*, 20–26.

Skinner, B. F. (1976). *About behaviorism*. Knopf.

Speer, N. M. (2005). Issues of methods and theory in the study of mathematics teachers' professed and attributed beliefs. *Educational Studies in Mathematics, 58*, 361–391. https://doi.org/10.1007/s10649-005-2745-0

Stipek, D. J., Givvin, K. B., Salmon, J. M., & MacGyvers, V. L. (2001). Teachers' beliefs and practices related to mathematics instruction. *Teaching and Teacher Education, 17*(2), 213–226. https://doi.org/10.1016/S0742-051X(00)00052-4

Sullivan, P., & Heffernan, A. (2016). Students' difficulties in geometry learning. In Á. Gutiérrez, G. C. Leder, & P. Boero (Eds.), *The second handbook of research on the psychology of Mathematics education* (pp. 815–842). Sense Publishers.

Thurm, D., & Barzel, B. (2024). Mathematics education with digital technology: Opportunities for teaching and learning. *Education and Information Technologies, 29*, 19035–19065. https://doi.org/10.1007/s10639-024-12577-3

Tracy, S. J. (2019). *Qualitative research methods: Collecting evidence, crafting analysis, communicating impact* (2nd ed.). Wiley-Blackwell.

Vitale, J. M., Swart, M. I., & Black, J. B. (2014). Integrating intuitive and novel grounded concepts in a dynamic geometry learning environment. *Computers & Education, 72*, 231–248. https://doi.org/10.1016/j.compedu.2013.11.004

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.

Walter (2024). Impact of digital technologies on mathematical problem-solving and learning outcomes in geometry. *Journal of Mathematics Education Research*, *5*(1), 23-29.

Zhang, Y., Wang, P., Jia, W., Zhang, A., & Chen, G. (2023). Dynamic visualization in GeoGebra and its impact on students' geometric reasoning: A meta-analysis. *Journal of Research on Technology in Education, 57*, 437–458. https://doi.org/10.1080/15391523.2023.2250886

Zulnaidi, H., Oktavika, E., & Hidayat, R. (2020). Effect of use of GeoGebra on achievement of high school mathematics students. *Education and Information Technologies, 25*(1), 51–72. https://doi.org/10.1007/s10639-019-09899-y

APPENDICES

A 2 -Week Action Plan for Action Research

Use of Digital MathsPad Tools for Improving Geometric Construction Proficiency in Grade X Students

Week	Purpose	Activities	Description	Expected Outcome
1A: Planning and Baseline Diagnosis	Identify learning gaps and prepare intervention	Problem identification	Review students' previous test papers and classroom difficulties in geometric construction	Students' initial conceptual and procedural gaps are clearly identified
		Pre-test administration	Conduct pre-test on line segment, angle construction, and basic quadrilaterals	
		Observation	Observe students' confidence, errors, and use of geometric instruments	
		Lesson planning	Prepare MathsPad-integrated lesson plans for	

			constructions	
		Orientation & ethics	Explain purpose of study to students and ensure consent	
1B: Action Cycle 1 – Basic Constructions with MathsPad	Build conceptual clarity through visualization	Teaching basic concepts	Points, lines, line segments, and loci taught using MathsPad visualization	Improved conceptual understanding and reduced fear toward basic constructions
		Line segment construction	Measuring and bisecting line segments using compass (MathsPad + manual)	
		Angle construction	Constructing angles using protractor and compass	
		Observation	Note student engagement, questions, and misconceptions	
		Reflection	Teacher maintains reflective journal on the effectiveness of MathsPad	
2A: Action	Strengthen	Angle	Bisecting	Students

Cycle 2 – Angle & Triangle Constructions	procedural accuracy and confidence	bisection	standard and non-standard angles using MathsPad	demonstrate confidence, accuracy, and active participation in constructions
		Triangle construction	Constructing triangles (SSS, SAS, ASA) step-by-step	
		Collaborative practice	Peer learning and group practice using MathsPad	
		Interviews	Short interviews with key participants (e.g., Saanvi, Prajwal)	
		Reflection	Daily reflection on student progress and challenges	
2B: Action Cycle 2 – Advanced Construction & Evaluation	Consolidate learning and evaluate impact	Quadrilateral construction	Constructing quadrilaterals and area-equivalent figures	Significant improvement in students' conceptual clarity, procedural fluency, and motivation
		Independent practice	Students perform	

			constructions with minimal teacher support	
		Post-test	Assess improvement in geometric construction proficiency	
		Data analysis	Compare pre-test and post-test results	
		Final reflection	Reflect on pedagogical change and student learning	

Students Engagement during Action Research Intervention

Pre – Test and Post – Test Questionnaire Sample

Pre-Test

Grade: X Time: 30 min

Subject: Mathematics Date: 2024/11/28 F.M.: 15

All questions are compulsory.

Q1. Draw line segments of following measurement and bisect them using compass. [2+2]

[a] 5 cm [b] 8 cm [c] 14 cm [d] 12 cm

Q2. Draw the following angles using protractor.

[2+2]

[a] $30°$ [b] $60°$ [c] $75°$ [d] $90°$

Q3. Draw the following angles using compass and scale and bisect the angles.

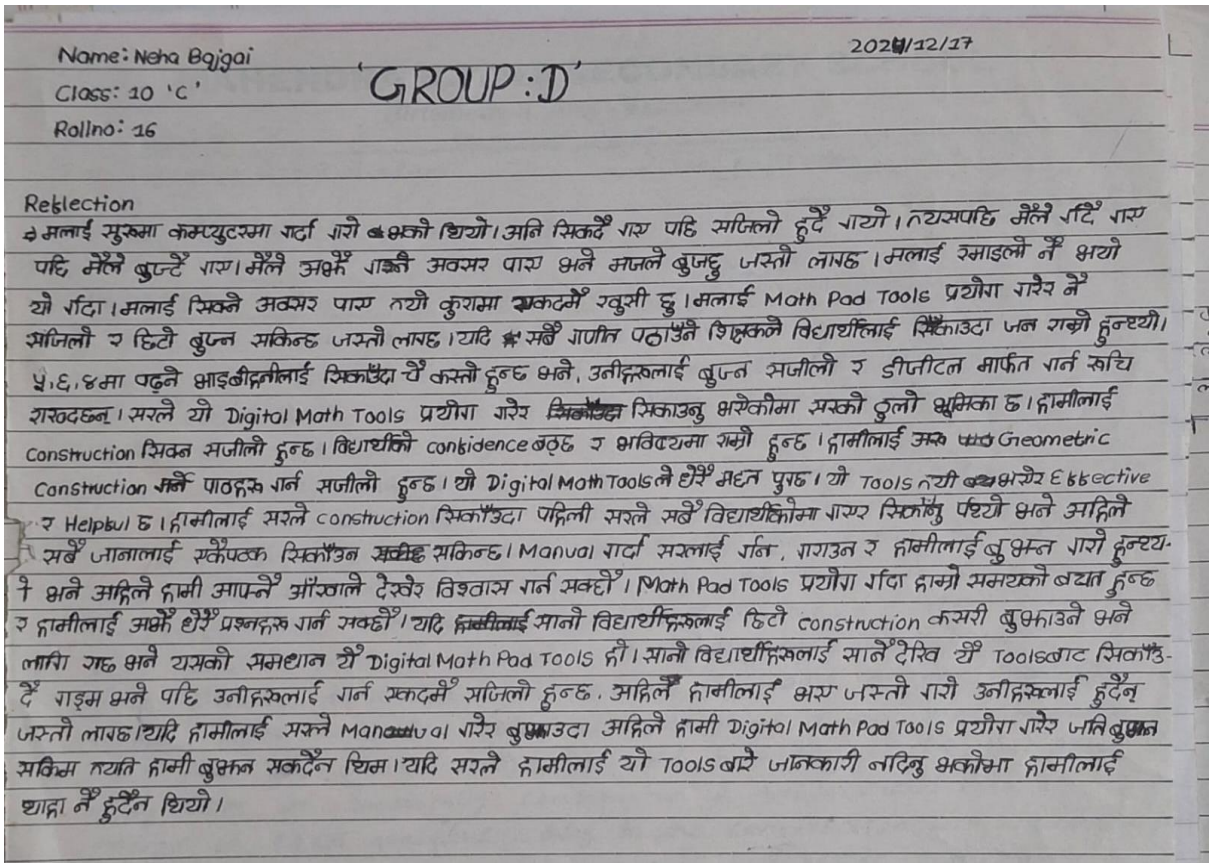
[2+2]

[a] $30°$ [b] $60°$ [c] $75°$ [d] $90°$

Q4. Construct a quadrilateral PQRS having PQ = 6cm, QR = 7cm, RS = 5cm, SP = 5.5cm and $\measuredangle PQR = 60°$. Also construct a triangle PQT equal in area to the area of given quadrilateral PQRS.

[3]

Students' Reflections after the MathsPad Class



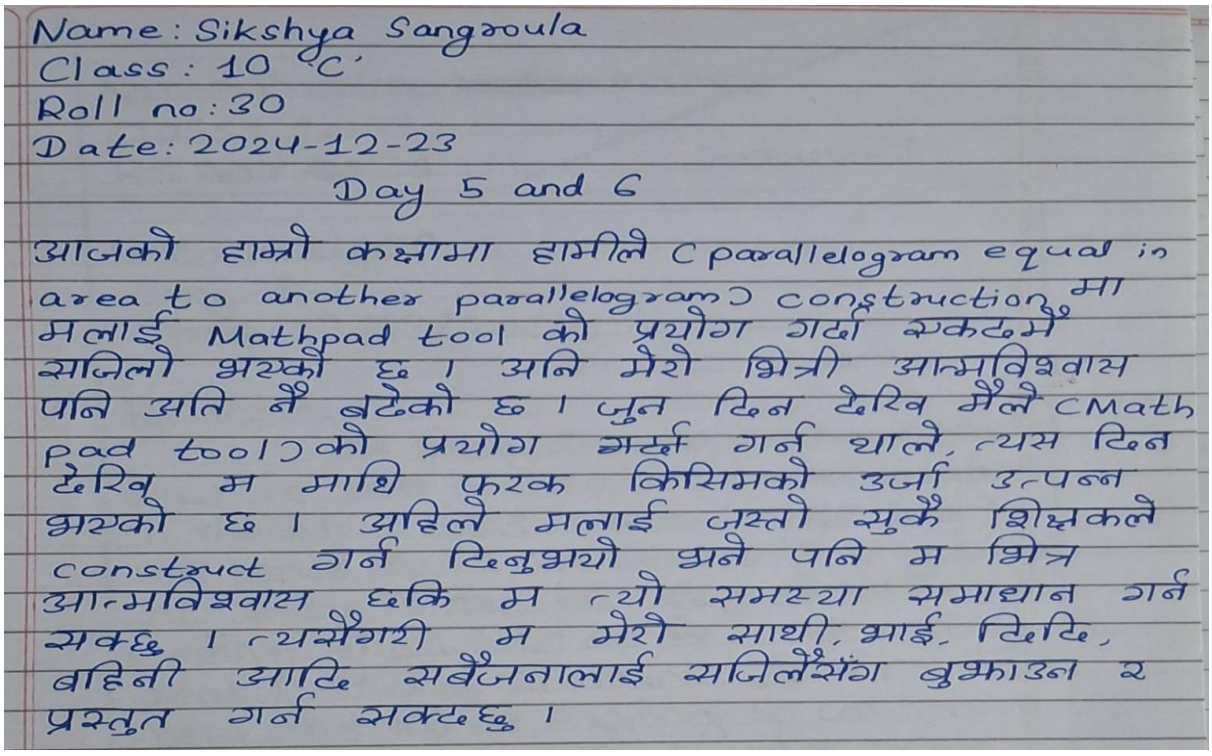
Name: Neha Bajgai
Class: 10 'C'
Rollno: 16

'GROUP: D'

2024/12/17

Reflection

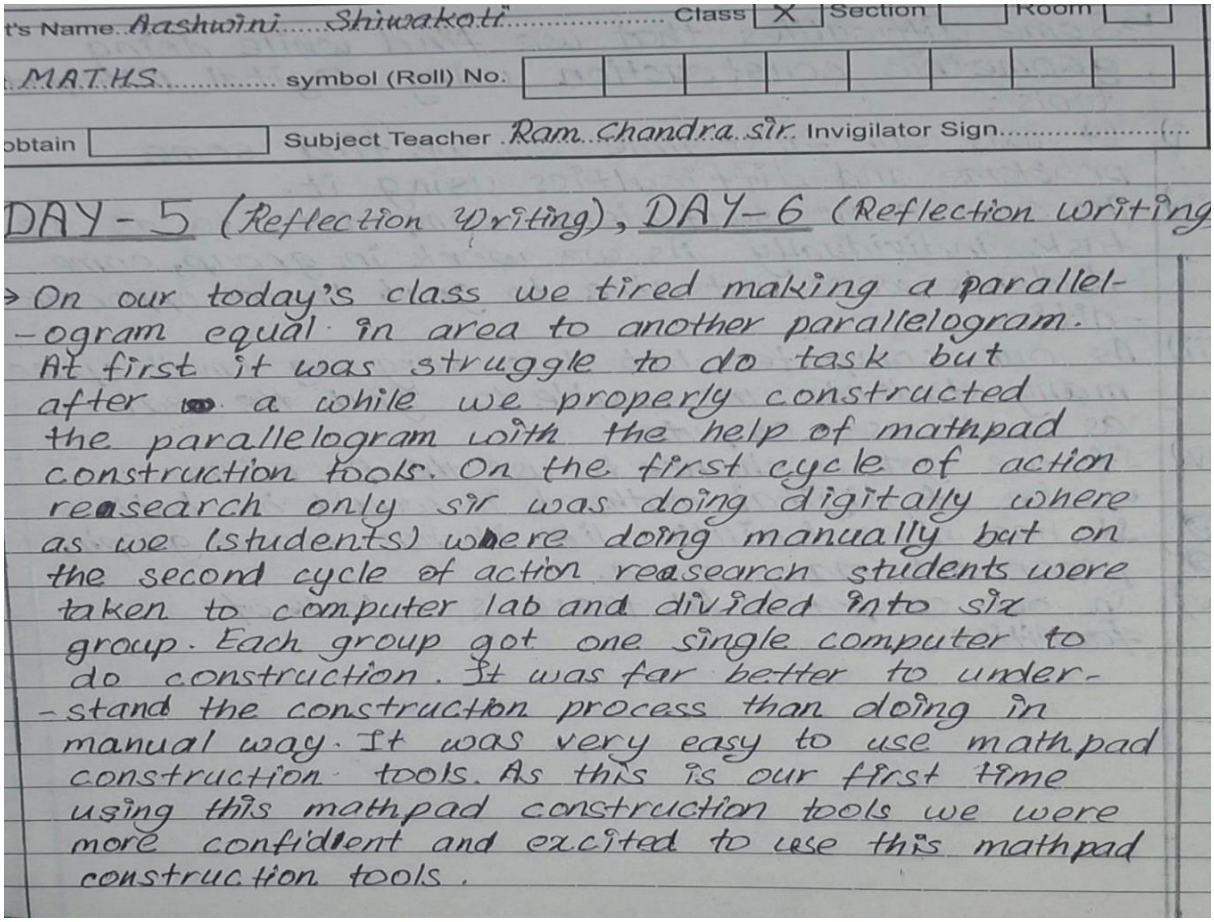
मलाई सुरुमा कम्प्युटरमा गर्दा गारो भको थियो। अनि सिकदै गए पछि सजिलो हुदै गयो। त्यसपछि मैले गर्दै गए पछि मैले बुज्दै गए। मैले अझै गर्ने अवसर पाए भने मजले बुजछु जस्तो लागछ। मलाई रमाइलो नै भयो यो गर्दा। मलाई सिक्ने अवसर पाए त्यो कुरामा एकदमै खुसी छु। मलाई Math Pad Tools प्रयोग गरेर नै सजिलो र छिटो बुज्न सकिन्छ जस्तो लागछ। यदि सबै गणीत पढाउने शिक्षकले विद्यार्थीलाई सिकाउदा जन राम्रो हुन्थ्यो। ५,६,४मा पढ्ने भाइबहिनीलाई सिकाउदा चै कस्तो हुन्छ भने, उनीहरुलाई बुज्न सजीलो र डीजीटल मार्फत गर्न रुचि राख्दछन्। सरले यो Digital Math Tools प्रयोग गरेर सिकाउनु भएकोमा सरको ठुलो भूमिका छ। हामीलाई Construction सिक्न सजीलो हुन्छ। विद्यार्थीको confidence बढ्छ र भविष्यमा राम्रो हुन्छ। हामीलाई अरु Geometric Construction पाठहरु गर्न सजीलो हुन्छ। यो Digital Math Tools ले धेरै मद्दत पुग्छ। यो Tools त्यी भएर Effective र Helpful छ। हामीलाई सरले construction सिकाउदा पहिली सरले सबै विद्यार्थीकोमा गएर सिकाउनु पर्थ्यो भने अहिले सबै जानालाई एकैपटक सिकाउन सकिन्छ। Manual गर्दा सरलाई गर्न, गराउन र हामीलाई बुझ्न गारो हुन्थ्यो भने अहिले हामी आफ्नै आँखाले देखेर विश्वास गर्न सक्छौ। Math Pad Tools प्रयोग गर्दा हाम्रो समयको बचत हुन्छ र हामीलाई अझै धेरै प्रश्नहरु गर्न सक्छौ। यदि सानो विद्यार्थीहरुलाई छिटो construction कसरी बुझाउने भने लागि राछ भने यसको समधान यै Digital Math Pad Tools हो। सानो विद्यार्थीहरुलाई सानै देखि यै Tools बाट सिकाउदै गइम भने पछि उनीहरुलाई गर्न एकदमै सजिलो हुन्छ. अहिले हामीलाई भए जस्तो गारो उनीहरुलाई हुदैन् जस्तो लागछ। यदि हामीलाई सरले Manual गरेर बुझाउदा अहिले हामी Digital Math Pad Tools प्रयोग गरेर जति बुझ्न सकिम त्यति हामी बुझ्न सकदैन थिम। यदि सरले हामीलाई यो Tools बारे जानकारी नदिनु भकोभा हामीलाई थाहा नै हुदैन थियो।



Name: Sikshya Sangroula
Class: 10 'C'
Roll no: 30
Date: 2024-12-23

Day 5 and 6

आजको हाम्रो कक्षामा हामीले (parallelogram equal in area to another parallelogram) construction मा मलाई Mathpad tool को प्रयोग गर्दा एकदमै सजिलो भएको छ। अनि मेरो भित्री आत्मविश्वास पनि अति नै बढेको छ। जुन दिन देखि मैले (Math pad tool) को प्रयोग गर्न थाले, त्यस दिन देखि म माथि फरक किसिमको उर्जा उत्पन्न भएको छ। अहिले मलाई जस्तो सुकै शिक्षकले construct गर्न दिनुभयो भने पनि म भित्र आत्मविश्वास छकि म त्यो समस्या समाधान गर्न सक्छु। त्यसैगरी म मेरो साथी, भाई, दिदि, बहिनी आदि सबैजनालाई सजिलैसँग बुझाउन र प्रस्तुत गर्न सक्दछु।



t's Name Aashwini Shiwakoti Class X Section Room

MATHS symbol (Roll) No.

obtain Subject Teacher Ram Chandra sir. Invigilator Sign

DAY-5 (Reflection Writing), DAY-6 (Reflection writing

→ On our today's class we tired making a parallel-ogram equal in area to another parallelogram. At first it was struggle to do task but after a while we properly constructed the parallelogram with the help of mathpad construction tools. On the first cycle of action research only sir was doing digitally where as we (students) where doing manually but on the second cycle of action research students were taken to computer lab and divided into six group. Each group got one single computer to do construction. It was far better to under-stand the construction process than doing in manual way. It was very easy to use mathpad construction tools. As this is our first time using this mathpad construction tools we were more confident and excited to use this mathpad construction tools.

In the beginning learning geometric construction was quite difficult for us because we were doing everything manually. Using the compass and ruler took a lot of time, & and sometimes our constructions were not very accurate. During this stage, our teachers demonstrated the process using Mathpad on the board, while we tried to follow along manually. We had to wait for our turns to understand each step properly which made the process a bit slow & challenging.

After about a week of classes, we finally got the opportunity to practice the constructions in the computer lab using Mathpad construction Tools ourselves. Our class was divided into groups & each group got a computer to work on. At first, it felt a little confusing to use digital compass & tools, but with some guidance & teamwork, we gradually became more comfortable.

Working digitally made the constructions much clearer & easier to understand. It was exciting to see how quickly & accurately we could complete the figures compared to manual method. The tools helped us visualize geometric shapes better & improved our overall understanding of topic.
By the end of the session, we all felt more confident and found the use of technology in gemometry learning useful. It not only saved our time but also made the class more engaging & enjoyable. We look forward to using Mathpad & similar tools again in the future to strengthen our maths skills.

Name: Samita Sarki
class: 10

Day 7

Date: 27/12/202

Reflection:

In our today's session, we were provided with Mathpad Tools in Computer Desktop. 6 groups were formed where I belong to Group A. At first my friends were nervous using mathpad construction tools but i was very familiar and i had used it before also. It was difficult for using compass at first time and our group was taking a lot of time. After sometime we construct a triangle equal area to the given ~~tri~~ quadrilateral. ~~Afte~~ After using mathpad construction tool we feel very clear and comfortable doing or using it.