CONCRETE, PICTORIAL AND ABSTRACT (CPA) LEARNING APPROACH FOR DEVELOPING STUDENTS' ENGAGEMENT IN LEARNING MENSURATION: AN ACTION RESEARCH

Niroj Shrestha

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AN ABSTRACT

of the dissertation of *Niroj Shrestha* for the degree of *Master of Education in Mathematics Education*, presented on *24 April 2026* entitled *Concrete, Pictorial and Abstract (CPA) Learning Approach for Developing Students' Engagement in Learning Mensuration: An Action Research.*

APPROVED BY

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Asst. Prof. Indra Mani Shrestha

Dissertation Supervisor

The innovative method of Concrete-Pictorial-Abstract (CPA) approach in mathematics education has opened the way of new possibilities for scaffolding students with an abstract concept more clearly. This action research investigates how this CPA approach can enhance Grade 10 student's conceptual understanding in mensuration topic. The study took place over a period of 15 days in a private English-medium school in Kathmandu valley, involving students, with six key participants selected for detailed observation and interviews.

The motivation for the research stemmed from the continuous decline in students' math scores in Nepal's Secondary Education Examination (SEE) 2024, as reported by the Ministry of Education, Science and Technology (MoEST, 2024). The study included interactive demonstrations, exploratory experiments, visual clarification and collaborative problem-solving skills. The findings show significant improvement in student's understanding in mensuration when CPA approach was applied. Students showed better performance in explaining and identifying geometric nets, and reasoning about cross-sections and slant heights. The class what I found is more engaging, and more enjoyable compared to traditional, lecture-based methods.

……. 24 April 2026

Niroj Shrestha

Degree Candidate

शोधसार

गणित शिक्षामा स्नातकोत्तर उपाधिका लागि निरोज श्रेष्ठको शोधप्रबन्धको शीर्षक “क्षेत्रमिति सिकाइमा विद्यार्थीहरूको सक्रियता अभिवृद्धि गर्न कङ्क्रिट-पिक्टोरियल-अब्स्ट्र्याक्ट (CPA) सिकाइ विधिको प्रयोग: एक कार्यमूलक अनुसन्धान” ११ वैशाख २०८३ मा प्रस्तुत गरिएको थियो।

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उप. प्रा. ईन्द्र मणि श्रेष्ठ

शोध निर्देशक

गणित शिक्षामा प्रयोग गरिने नवीन ‘कङ्क्रिट-पिक्टोरियल-अब्स्ट्र्याक्ट’ (CPA) विधिले अमूर्त गणितीय धारणाहरूलाई स्पष्ट रूपमा बुझाउन नयाँ सम्भावनाहरूको मार्ग खोलेको छ। यस कार्यमूलक अनुसन्धानले क्षेत्रमिति विषयमा कक्षा १० मा अध्ययनरत विद्यार्थीहरूको अवधारणात्मक बुझाइलाई CPA विधिले कसरी अभिवृद्धि गर्न सक्छ भन्ने कुराको खोजी गरेको छ। यो अध्ययन काठमाडौं उपत्यकाको एक निजी अंग्रेजी माध्यमको विद्यालयमा १५ दिनको अवधिमा सञ्चालन गरिएको थियो, जसमा कुल २४ विद्यार्थीहरू सहभागी थिए। तीमध्ये ६ जना मुख्य सहभागीहरूलाई विस्तृत अवलोकन र अन्तर्वार्ताका लागि चयन गरिएको थियो।

यस अनुसन्धानको आवस्यकता अथवा प्रेरणा शिक्षा, विज्ञान तथा प्रविधि मन्त्रालय (MOEST, 2024) को प्रतिवेदन अनुसार नेपालको माध्यमिक शिक्षा परीक्षा (SEE) मा गणित विषयको नतिजामा निरन्तर भइरहेको ह्रासबाट भएको हो। यस अध्ययन अन्तर्गत अन्तर्क्रियात्मक प्रदर्शन, प्रयोगात्मक परीक्षण, भिजुअल स्पष्टीकरण र सहयोगात्मक समस्या-समाधान जस्ता क्रियाकलापहरू समावेश गरिएका थिए। यी गतिविधिहरूले विद्यार्थीहरूलाई ठोस सामग्रीको प्रयोग, चित्र वा भिजुअलको परिचालन र गणितीय संकेत वा सूत्रहरूको प्रयोग मार्फत वास्तविक समयमै विषयवस्तुलाई गहिराइबाट बुझ्न मद्दत गर्छ जस्तो लाग्छ। अनुसन्धानले CPA विधि प्रयोग गर्दा सोली र पिरामिडको विशेषता तथा सूत्रहरूसँग सम्बन्धित विद्यार्थीहरूको बुझाइमा उल्लेखनीय सुधार भएको देखाएको छ। विद्यार्थीहरूले आयतन र पूरा सतहको क्षेत्रफलको अवधारणा व्याख्या गर्न, ज्यामितीय नेटहरू पहिचान गर्न, र क्रस-सेक्सन एवं छड्के उचाइको तर्कपूर्ण विश्लेषण गर्न राम्रो क्षमता प्रदर्शन गरेको देखिन्छ। परम्परागत व्याख्यान विधिको तुलनामा यो कक्षा बढी आकर्षक, अन्तरक्रियात्मक र मनोरञ्जनात्मक पाइएको थियो।

..... ११ वैशाख २०८३

निरोज श्रेष्ठ

उपाधि उम्मेदवार

This dissertation entitled *Concrete, Pictorial and Abstract (CPA) Learning Approach for Developing Students' Engagement in Learning Mensuration: An Action Research,* was presented by *Niroj Shrestha* on *24 April 2026*.

APPROVED BY

……. 24 April 2026
Asst. Prof. Indra Mani Shrestha
Dissertation Supervisor

……. 24 April 2026
Rameshower Aryal
External Supervisor

……. 24 April 2026
Asst. Prof. Roshani Rajbanshi, PhD
Head, Department of STEAM Education

……. 24 April 2026
Prof. Bal Chandra Luitel, Ph.D.
Dean/Chairman of Research Committee

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

……. 24 April 2026
Niroj Shrestha
Degree Candidate

DECLARATION

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

……. 24 April 2026

Niroj Shrestha

Degree Candidate

DEDICATION

This dissertation is solely dedicated …

To my source of inspiration and motivation, my respected mother Hira Devi Shrestha,

My better-half Sharu, who always energizes me to proceed on new and innovative journey in every second of my life!

They all are always for me with their regular help, support and guidance and

To all the educators who have selected the teaching profession and trying to functioning for new turn in pedagogical perspective!

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I also owe a lot of gratitude to a number of people whose support, advice and feedback played a significant role in the progress of this dissertation. I greatly appreciate all the people who directly or indirectly contributed towards this research process. This work would not have had its shape without them.

It is my great pleasure to say that my dissertation supervisor, Assistant Professor Indra Mani Shrestha, was extremely helpful, full of valuable feedback, and diligent in his work. Through my regular supervision, I remained focused, motivated and involved in the studying process.

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Niroj Shrestha
Degree Candidate

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ABBREVIATIONS

CERID	Center for Educational Research and Development
CPA	Concrete, Pictorial, Abstract
DDLE	Data collection, Discussion, Literature justification, and Experience sharing
ERO	Education Review Office
FGD	Focus Group Discussion
ICT	Information and Communication Technology
KTP	Kathmandu Town Panchayat
LBL	Lab-based Learning
LSA	Lateral Surface Area
MKO	More Knowledgeable Other
MoEST	Ministry of Education, Science and Technology
NASA	National Assessment of Student Achievement
NCTM	National Council of Teachers of Mathematics
NEB	National Examinations Board
OECD	Organization for Economic Co-operation and Development
PBL	Project-based Learning
PISA	Program for International Student Assessment
SEE	Secondary Education Examination
SLC	School Leaving Certificate
STEAM	Science, Technology, Engineering, Arts, Mathematics
TSA	Total Surface Area
UNCF	United Nations Children's Fund
ZPD	Zone of Proximal Development

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CHAPTER I
INTRODUCTION

This chapter begins with its introductory part, starting with the background of the study, then statement of the problem, study objectives, significance of the study, delimitation of the research, and definition of the related terms.

Background of the Study

I am from Kathmandu. I completed my education up to Master's Degree in this city. My schooling level was effective. Mathematics was my favorite subject from my early years. I was fond of mathematics and enjoyed doing calculations, solving problems, and proving theorems. I was a good student and was appreciated by my teachers and parents too because I used to get good marks in mathematics. Now, I have come to know that I am a good algorithmic problem solver. The majority of the mathematics concepts in the Nepali curriculum are contained in the abstract form. At this point, I realized that my teacher just focused on straight forward traditional method rather than following the artistic and contextualization method. It was clear that the learning was focused on the examination procedures and we (me and my friends) used to memorize them as said by our teacher without any understanding. Then after, I too followed the same process in my teaching career. In the beginning, though I was laboring my best to get the desired output from the students the achievement of my students in mathematics was just the opposite of it. After joining the masters, I knew that there must be an engaged type of approach in the teaching-learning process like learning by doing, lab-based learning, game-based learning, project-based learning, etc. In my opinion, the above scenario might be common in our school and my experience might represent the experience of an ordinary student or a teacher of any secondary school in our country.

Schools are organizations that include different human resources. The main human resources are the teachers and their students. Teachers work in the school every day to improve the positive outcomes for the learners. Among the outcomes, mathematics learning is one of the major outcomes at the school level. Mathematics is one of the important subjects at the secondary level which plays a crucial role in enhancing student's problem-solving skills, critical thinking skills, and logical reasoning abilities. According to Best and Khan (1998), early mathematics can be said

to have originated in certain areas of agricultural and engineering pursuits. The nature and structure of mathematics was built with the development of human civilization. Ancient civilizations such as Babylonian, and Egyptian contributed to the development of mathematics (Guragain, 2001).

Nowadays, the education system is expanding and changing rapidly worldwide. The result and learning environment of the students show that their interest in mathematics is declining day by day (Pokharel, 2023). It is necessary to understand the factors addressing this issue effectively. There is a need to investigate the causes and effects of this problem in learning mathematics among secondary-level students in Nepal. The research will also discuss the various methods and ideas of uplifting the engagement in learning mathematics effectively.

Let's start with some factors that decrease engagement in mathematics learning among secondary-level students in Nepal. Initially, traditional pedagogical approaches like lecture-based teaching strategies, rote memorization, and summative pencil-paper tests may affect engagement in this subject (Freeman et al., 2014). So, there is a need for positive pedagogical change in the learning styles such as inquiry-based, student-centered, real-world application-based, concept-based, etc. to increase the student's engagement and motivation. Similarly, parental attitudes, gender discrimination, and societal perceptions of mathematics are also some of the factors affecting the student's perception, participation and interest in mathematics education. In Nepal, it is found that socio-economic disparities and cultural norms influence the favorable learning environment of the students. To identify the reason for the decreasing engagement in mathematics subjects in secondary-level education, a qualitative type of research approach is needed to be conducted. It includes interviews, focus group discussions and observations for exploring student's perceptions, attitudes and experiences in mathematics learning. The research on applying the CPA learning approach helps to increase engagement in mathematics subjects in secondary-level education in Nepal. This can able to address the pressing issue and give significant outcomes for the educational system of Nepal.

Concrete-Pictorial-Abstract (CPA) learning is a three-step teaching methodology. created by Jerome Bruner (1966) which makes use of systematic scaffolding to assist students to overcome the abstractness of mathematics. The framework supports the development of a learner in three interrelated phases: the concrete stage entails doing where students handle physical. objects such as clay,

cardboard, or skeletal models, to solve problems; the Pictorial stage involves bridging the gap by visualizing where students apply visual representations or digital tools such as GeoGebra between physical objects and symbols; and the Abstract stage is the reasoning of symbols with numbers and mathematical notation. This method assists students to learn abstract concepts through making them based on real-life experience, in effect demystifying the abstract mathematical formulas. By focusing on conceptual knowledge rather than memorization, CPA learning enhances students' mathematical reasoning, clarifies the relationships between geometric elements, and greatly rejuvenates student interest in the classroom.

Problem Statement

Before starting my research, me as a teacher often played in mind on why our students of secondary level not giving interest or engaging in mathematics subject nowadays. This problem made me somehow frustration in my teaching life as mathematics teacher. Actually, this subject is regarded as a core subject in the study up to the secondary level. Despite being a core subject in secondary-level education, mathematics is witnessing a decline in student engagement across schools in Nepal. According to the National Examination Board (NEB), a total of 4,64,785 students have participated in Secondary Education Examination (SEE) in Compulsory mathematics in the year 2024 but 177,985 (about 40%) students get a grade ‘NG’ which has low achievement in comparison to other subjects shows that students get low achievement in mathematics (National Examination Board [NEB], 2024). This statistical data shows that there is a low engagement due to the lower interest level in mathematics in secondary level students creating a critical challenge to teachers, stakeholders, educators as well and policymakers to enhance the quality of education and interest in students. The problem statement focuses on investigating the factors, their effects, the importance of educational pedagogies, and academic achievement.

Similarly, my research problem is strongly supported by the findings of the National Assessment of Student Achievement (NASA) 2020 report. The data reveals that 68% of students fall into the below basic and basic levels of proficiency with poor competency level in Mathematics (Education Review Office [ERO], 2020). The report confirms that most of the students did not achieve the minimum expected learning level for Grade 10. Furthermore, most test items proved difficult for the participating students with the majority observed to be lagging below the average latent ability and demonstrating an alarming gap between the intended and achieved

curriculum. This combination of low mastery (low engagement/achievement) and high perceived difficulty (lower interest level) confirms that the struggle faced by secondary students in mathematics is a genuine concern requiring intervention.

I had been teaching mathematics subject for about twenty years. In the past, what I found is that the students are giving deep interest in mathematics but the number of these kinds of students is decreasing nowadays. Most of the students are not paying any attention to mathematics education. This makes it so difficult for me to make the students good and active in this subject. In my observation, most of the students have a negative feeling in mathematics subjects in the class. This problem is occurring due to our inappropriate teaching methodologies such as lecture, rote memorization, summative examination evaluation, etc. and outer environments such as parents, school administration, government, etc. It might identify the reason and might provide possible solutions to the problem. It might also change the needs of school settings and student demographics. Moreover, it might emphasize the potential implications of declining engagement in mathematics for educational practices, student motivation and academic achievement which might underscore the urgency of finding effective solutions. So, the problem statement helps to serve as a guiding framework for conducting the study and generating insights to inform evidence-based interventions and policy reforms in mathematics education in Nepal.

Purpose of the Study

The main purpose of my research study was to explore how Grade X students develop their engagement in learning mensuration through concrete, pictorial and abstract (CPA) learning approach. Its objectives are to assess the prior knowledge about the content of mensuration, determine the effect of lab-based activities like constructing 3D models with clay, papers, etc. with their results, explore the role of digital tools like GeoGebra through dynamic visualizations and compare the teaching techniques for diverse learners.

Research Question

How does the Concrete-Pictorial-Abstract (CPA) learning approach develop Grade X students' engagement in learning mensuration?

Significance of the Study

The study is expected to provide helpful information for teachers, educators, and policymakers to promote a favorable environment and practices in secondary-level education in Nepal. First, a researcher addressed about the current status of

engagement in mathematics. Then, the observations of the study found the way to reduce the problems and gave the right direction to create policy reforms in the country. It might help to promote the student's engagement in mathematics learning. Furthermore, the improved engagement in mathematics might have broader societal impacts like developing skilled manpower, promoting economic development, and creating global competitiveness. Ultimately, the research study might improve the overall context of the education system of Nepal.

Delimitation of the Study

The delimitation is the process by which a researcher determines the scope of his study area and what kind of tools he wants to study based on the available resources and time (Khanal, 2019). The research study on the scenario of engagement in mathematics subjects in secondary-level education in Nepal might face certain delimitations. Logistical constraints or difficulty might be one of the delimitations caused by the geographical scope of the study. Another delimitation might be the age group of selecting the secondary-level students only but not primary and higher-level students. Moreover, the research might be delimited by the availability of resources and access to participants, particularly in remote or rural areas.

Chapter Summary

In this chapter, I had written a brief description of my research topic. Here, I tried to make clear about the problem statement, the purpose of the research study, a possible research question, the delimitation of the research study and the significance of the research study. This chapter provided information about some of the basic conditions and reforms of the existing current issues of the study.

CHAPTER II
LITERATURE REVIEW

The process of locating, obtaining, reading, and evaluating the research literature in the area of the research is called literature review. Its main purpose is to develop some expertise in one's area to see what new contributions can be made and to receive some ideas for developing a research design. Also, the purpose of this chapter is to analyze the research literature relevant to the purpose and question addressed in this study.

The theory plays a remarkable role in the research work. The study of existing literature provides a right track in the upcoming research process. Though the literature doesn't play major role in this research study, it supports this research to identify the findings and claims. Firstly, this chapter reviews the thematic domain, then theoretical and finally empirical reviews of previous research conducted in the area.

Thematic Review

The review effectively explains the important role of mathematics in human knowledge and its historical significance (Pandit, 2007), alongside addressing the problem of student disengagement and low proficiency, particularly evident in Nepalese secondary schools (Khanal, 2015). In the paper of Ghimire (2010), it is written that the review focuses the massive influence of mathematics in daily life and advanced studies, contrasting with disappointment performance metrics in mathematics examinations such as Nepal's School Leaving Certificate (SLC). In this section, I reviewed the literature related to my study which I had discussed about CPA approach at first along with some other important headings.

Concrete-Pictorial-Abstract (CPA Approach)

Concrete-Pictorial-Abstract (CPA) is a much-admired instructional pedagogy that has been known to generate an in-depth and long-term knowledge of mathematical concepts in learners (Bruner, 1966). The model is based on the work of an American psychologist Jerome Bruner (1966), namely, his theory of the so-called enactive-iconic-symbolic modes of representation. The main understanding of the CPA approach includes systematic scaffolding learning to overcome the main

abstractness of mathematics. It consists of three major interconnected stages which are described by the abbreviation CPA.

Concrete (C) is the doing part, during which the students construct and physical intervention into actual objects or materials (e.g., cubes, counters, real fruit) to represent and solve problems. This practical experience is what makes concepts alive and develops conceptual knowledge. Similarly, the seeing phase, pictorial (P), involves students to represent the tangible objects that have been manipulated using visual representations, e.g., diagrams, drawings, or models (such as the 3D model). This step is critical for linking the physical resources to the symbolic notation.

The final symbolic stage, abstract (A) involves using abstract notation, numbers, and mathematical symbols i.e. four fundamental mathematical operations (+, –, x, ÷). This level is only supposed to be taken after the students have effectively acquired the knowledge based on the tangible and visual experiences. Though depicted as three different steps, an important learning practice is that a literate teacher will switch back and forth between the stages to keep reinforcing concepts in a continuous manner to students, and CPA is more of a combined method, not a strict progression. Research demonstrates that applying the CPA approach effectively enhances school student's mathematical reasoning ability and helps them develop flexible thinking in problem-solving processes. Nur and Nur (2019) also conducted experimental research that support by showing that students taught with CPA performed significantly better in reasoning tasks and mathematical problem solving than those taught with traditional methods.

Lab-based Learning Approach

The lab-based learning in mathematics mainly focuses on hands-on engagement with the practical mode of learning. In this approach, the learners learn the mathematical concepts with experimentation and discover new things with deep understanding. It also encourages learners to investigate, analyze and apply the ideas in the real world. This approach closely aligns with inquiry-based learning. In the mathematical lab, the learners work collaboratively, think collectively and use or design the manipulatives and construct their knowledge from the concrete materials (manipulatives). The activities in the lab help to reduce the gap between theoretical knowledge and practical application in the learners. Das (2019) also supports the

utility of math labs in education, emphasizing that they offer both students and teachers a tool to engage with mathematical ideas more dynamically and interactively.

Student Motivation and Engagement

Student motivation and engagement is regarded as one of the important areas to understand the cause of decreasing engagement in mathematics at the secondary level. It explains the anxiety and lower self-esteem related to the subject. The Program for International Student Assessment (PISA) 2015 results indicated that one in five pupils had serious difficulties in developing sufficient mathematics or science skills (Organization for Economic Co-operation and Development [OECD], 2016). It describes the impact of teaching methods, classroom environment, assessment practices and extracurricular activities on students' participation in mathematics. Perceived relevance, self-efficacy and interest in the subject are some of the factors that determine the level of motivation in students (Wigfield & Eccles, 2000). It further discusses the attitudes, beliefs, and experience of student regarding mathematics learning and provides effective strategies of fostering motivation and engagement. Motivation is very important in the readiness of a student to work and perform well in mathematics (Anderman & Anderman, 2010). According to Martin (2008), "It was found that the self-complete intervention brought about significant shifts in motivation and engagement" (p.239-269).

Teacher Training and Professional Development

Regular teacher training and professional development is also one of the important topics in this research study. It addresses the issue of decreasing engagement in mathematics at the secondary level effectively. According to Hattie (2009), teachers play a pivotal role in shaping student's attitudes toward the subject. It is found widely that well-trained teachers can apply innovative and transformative teaching methods in the class so that they can make mathematics more engaging for students. Professional development programs should focus on equipping teachers with the skills to create interactive and student-centered learning experiences.

This is concerned with the role of instructors in promoting student involvement in mathematics in secondary level students. It entails evaluation of the quality of mathematics teaching through the attitudes of a teacher and attitudes toward the topic and discovering the loopholes in teacher education and development programs. It also explores ways of increasing teacher performance and love of

mathematics teaching. According to Berry, et al., (2010), “The evidence reveals that high-quality pre-service training increases new teacher retention and improves their effectiveness.” (p.12). Thus, by constantly updating their knowledge and the methods they use during teaching, the teachers will be able to meet the needs of their students that vary and create a positive involvement and attitude to mathematics.

Curriculum Relevance and Adaptation

The curriculum and adaptation of the mathematics subject play a vital role in the different levels. They might create gaps in the learning of students. In my opinion, the curriculum and educational strategies had changed many times but still, there is a lack of concentration and appreciation in mathematics. It might be due to the perception that a difficult subject remains unchanged. According to National Council of Teachers of Mathematics (NCTM), the curriculum should be designed to be engaging, meaningful, and aligned with student’s interests and future aspirations (NCTM, 2000). In order to render the curriculum more topical and appealing, the real-life applications and problem-solving tasks that illustrate the usefulness of mathematics in the practical life should be introduced. According to Boaler (2016), adapting the curriculum including real-world problems, interdisciplinary connections and opportunities for students’ inquiry could enhance their motivation and engagement with mathematics.

Engagement in Learning Mensuration

Student engagement is the level of effort, interest, and attention that students invest in the learning process (Klem & Connell, 2004; Marks, 2000). In the topic of mensuration, there are so many tasks in the real-world applications that involve the calculation of areas and volumes of the physical objects in grade X. The practical work done in mensuration could enhance engagement due to an increase in interest in the content. This alignment between practical tasks and theoretical concepts helps students see the relevance of mensuration by boosting the engagement levels. Finley and Reason (2016) argue that community-engaged signature assignments should be considered a high-impact pedagogical practice as such learning activities immerse ‘*students deeply in the real-world implications of complex problems and their solutions*’. When learners engage together, they benefit from peer support, have a deeper understanding and increase motivation. Moreover, the emotional

components of engagement, such as interest and enjoyment play a vital role in the feeling of autonomy.

Theoretical Review

This section consists of the theoretical perspectives of my study. In this section, I as a researcher try to connect different theoretical ideas with supportive literature. Walberg Model (1981) has defined learning as a function of personal variables and instructional treatment. He proposed a theory of educational productivity that has the theoretical foundation of Lewin's (1963), formulation of behavior as a function of personality and environment. However, despite its foundational significance, there exists a concerning trend of decreasing engagement in mathematics subjects among secondary-level students. The theoretical review directs the way to provide a comprehensive analysis of the opportunities and challenges in addressing the research issue. The important theory for my research topic is Vygotsky's social constructivism which is explained below in detail.

Vygotsky's Social Constructivism

As a researcher, I followed the social constructivism theory. Vygotsky's social constructivism theory emphasized the role of social interaction and cultural context in the construction of knowledge. According to Vygotsky (1978), cognitive development occurs as a result of social interactions, and learning is innately collaborative. He believed that children develop thinking skills through guided conversations and shared activities with more knowledgeable others, such as teachers or peers. Vygotsky posited that culture is the primary determining factor for knowledge construction, and learning cannot be separated from its social context. It also suggested that collaboration, social communication and cultural context play a vital role in constructing new knowledge in society through MKO. Educators could create meaningful engagement, active participation and sharing of culture or experiences to support a deeper understanding of mathematics education. Furthermore, this review visualizes two different learning agendas, social constructivism and the Zone of Proximal Development (ZPD). The concept of ZPD, introduced by Lev Vygotsky, explains that learning occurs within the range of what a learner can do independently and what they can do with the support of a more knowledgeable peer or teacher. Scaffolding is another aspect of Vygotsky's social constructivism which is closely related to the ZPD concept. It describes the gap between what a learner can do

independently and what they can achieve with guidance. Scaffolding works within this ZPD, helping earners progress beyond their current capabilities with appropriate support. They both focus the social nature of the learning. A part of my action research is performed in the laboratory which is out of the classroom. So, there is a need for social interaction with others. There might be the task of a collection of locally available materials to make different manipulatives in the lab related to mensuration. At this stage, I along with my students went to the society and collect the concrete materials available in the society. This was one of the major parts of my action research. So, I think that the mentioned theory helped me a lot throughout the research process.

A detailed research process started with an effective participatory method which moved from hands-on construction to digital visualization and finally to abstract problem-solving. The research methodology mainly focused on developing student knowledge collaboratively and systematically moving from tangible understanding toward abstract fluency which constantly aligned with the principles of Vygotsky's Social Constructivism. Mainly, there was a social interaction in many steps of learning which made the students always active. Similarly, the sightseeing of physical objects in the society justified this theory clearly. The field works like scaffolding the new ideas from one to another in construction and visualization the concepts also signified the application of this theory. One of the participants said, "We discussed the nets of square-based pyramids." Other participants said, "We got to do the complete revision through discussion." These some of the narratives of students also proved the authentic use of the theory in the research. In this way, the use of the CPA approach provided the necessary scaffolding and emphasized the role of social interaction and tool linked learning to successfully transition Grade X students from struggling with abstract formulas to confidently solving complex mensuration problems.

Empirical Review

In this section, I have reviewed the articles, dissertations and other research studies related to the research topic. The review study helps me to formulate research questions and research gaps. This review is a critical review in which the literature critically provides the foundation on which the research is built. Pant (1978) conducted an experimental study to assess the impact of using unit test results on improving student achievement in mathematics at the seventh-grade level in a

secondary school within Kathmandu Town Panchayat (KTP). Employing systematic sampling, Pant selected eight students from the school and taught them eight units from the textbook curriculum.

Giri (2008) conducted research based on the examination of SLC compulsory mathematics results. The result was unsatisfactory in mathematics because most of the students failed in this subject. He studied various aspects of the educational system like evaluation methods, management practices, course contents and many more. After doing the research, his findings are focused on a student's academic performance, including gender, parental education and occupation, school location, religion, socioeconomic status, teaching quality, learning environment, class size and medium of instruction.

Poudel (2017) conducted a study on the detrimental factors contributing to poor performance in mathematics. The research aimed to identify and understand the factors responsible for low achievement in mathematics as well as to propose strategies for improvement in school mathematics education. The survey was done on 200 students in six schools of Chitwan district which was based on internal and external factors of the school environment. The obtained data was analyzed with the help of mean and standard deviation which shows that external factors play a more significant role than internal school-related factors in poor mathematics performance.

Luitel (2016) had performed action research concerning activity-based instruction. to meaningful mathematics teaching. He attempted to enhance his improvise in his research, pedagogical techniques and classroom instruction by activities. The research project is carried out in Kathmandu district elementary private school studying grade seven students in the school. He implemented the fifteen-days plan in instructional approaches to teaching activities in the classroom. The aim of the study was to encourage the students to study mathematics by doing. He supposed that the activity-based instruction requires high action of learners in the learning process and makes them the center of the learning process. Based on an underlying set of data gathered by participants in the form of interviews making an inference, deriving through observation, pre-post evaluation and narrative sense making, he concludes that the study assisted him to better his practices of learning and teaching through activities. He is satisfied with the meaning planning strategies and learning mathematical conceptions by the activity-based learning. The study provides this research with insight in plan of action within the framework of CPA of my research.

Pokhrel (2001) had researched entitled, "Mathematics achievement in school leaving certificate examination between public and private school student at Kaski district." The overall finding of this research was the average scores in achievement by students in compulsory and optional mathematics. A correlation of private school students is greater than public school student in Kaski district in S.L.C. examination. He concluded that the performance of the private school mathematics is higher than the public one. As Richard. (1983) had already established a study based on factors that were related to school of the student achievement, he came to the significant variables associated with school of student's performance in mathematics behavior in class, student attention, method of teaching, teacher's background (trained, experience ability) of characteristics of student (prerequisite knowledge of students) of different schools.

In 2001, research on "A study on the effectiveness of class work while teaching geometry at the secondary level" was done by Poudel with the objective to study whether or not the class work become effective during the teaching of geometry. The research conducted experimental studies. The two groups were taught geometry by the researcher in two different ways. The ways are experimental and control. The regular unit class works were taught to the experimental group inside the normal classroom but the control group was maintained disconnected as much as possible from the classroom work activities (Paudel, 2001).

Neupane (2006), the studies are influenced by a number of factors. He discovered in their study that curriculum, instructional strategies and methods, teacher competency in math education, motivation or concentration method, participation instrument procedure analysis, self-directed learning, an arithmetic ability and out of school related factors are associated with gender, socio-economic status, parent's educational level. His study revealed that the instructional design of a mathematics course is significant and must be compatible with the factors found to be related to mathematics achievement. Teachers must be flexible and develop other innovative learning and teaching methods to teach mathematics effectively. The results also indicate that various instructional design strategies ought to be researched and implemented in various settings.

Research Gap

The pedagogical benefits of Concrete, Pictorial and Abstract (CPA) approach to learning mathematics have been known since its formulation but deliberate use of

this approach in the secondary school mathematics system in Nepal has been under-researched. A comprehensive literature search on these issues and a systematic assessment of local literature and institutional repositories, however, uncover several different aspects of this larger research gap. One is that there is a clear predominance of descriptive and diagnostic research study over the action-oriented solution, in the Nepalese educational discourse. The majority of studies on localized mathematics education research are aimed at discovering how these factors in the system contribute to low student performance, math anxiety, and poor engagement, including socio-economic issues, cultural anxiety, and the overuse of traditional lecture-based pedagogies. These studies are useful in revealing some deep-seated problems, but they fail to offer any practical solutions. There are few classroom intervention studies that purposefully implement and test systematic pedagogical approaches as a direct intervention to address these well-documented issues.

Second is that there is a pedagogical gap for Secondary level mensuration. Spatial and geometric reasoning is considered as one of the most difficult topics in secondary mathematics, but the literature in Nepal largely focuses on the overall achievement of mathematics or concepts in arithmetic and algebra. No local study has focused on using CPA as a focused teaching approach to alleviate the cognitive shift from memorization of rote formulas to conceptual fluency in grade 10 mensuration. In particular, there is no literature that deals with the abstract properties of three-dimensional objects like cones and square based pyramids for Nepalese learners and how it can be clarified by scaffolding.

In addition, the methodological point of view is lacking in classroom-based Action Research. Most of the mathematics literature available in Nepal is of non-participatory, external or purely experimental type. As a result, little research has been published about the role of the active teacher researcher in a cyclical, reflective, and transformative design, directly in their own educational context. The following omission remains: There is a lack of evidence that a practitioner can move between instructional strategies easily and quickly based on observations of the classroom as it occurs.

Last but not least, there is an obvious gap between the situations and realities of classrooms in resource-poor Nepal versus the situations and realities of classrooms in resource-rich classrooms. The majority of the basic literature related to the CPA approach comes from well-resourced educational environments of the West or East

Asia (such as Singapore Math). Little to no research exists about how a three-step scaffolding model, which heavily depends on concrete materials and dynamic visualization tools such as GeoGebra, can be creatively implemented in Nepalese schools' operational scopes. The existing literature does not account for the particular logistical problems, time constraints for curricular implementation, and fixed national examination systems and the anxiety students experience when implementing intensive active learning strategies in this context. This study directly connects to the persistent gap between the national curriculum and conceptual engagement at the student level in the secondary mathematics classroom, by engaging in an intentional action research cycle that strives to address these combined thematic, methodological, and contextual limitations.

Chapter Summary

While going through different related papers from various mediums, I found lots of problems in the process of teaching-learning activities in mathematics education worldwide. Many researchers worked hard in this field and displayed a significant result in finding the related person or organizations. These findings make it easy to determine the research gap and do the research on a particular topic that I have to conduct. In addition, I was able to generate different distinct themes for my research that may help me in the research process. As a result, this study directs me to address the gap by investigating the factors impacting mathematics achievement at the secondary level, particularly in private schools within the Kathmandu district.

CHAPTER III
RESEARCH METHODOLOGY

This chapter starts with the research paradigm, philosophical considerations, design of the study, study area, research participants, data analysis and interpretation procedure, quality standards, and ethical considerations of the research. Qualitative research focuses on interpretative and criticism approaches. Both approaches of research studies identify the facts or causes of social phenomena. So, I have selected both these approaches as part of the qualitative type of research. I did action research as a dissertation because it had helped me to find out the deep reasoning of the research problem practically.

Philosophical Considerations

How do we view the world? How do we generate knowledge? How do we value the findings? These are some of the questions which a researcher thinks of as philosophical considerations. It is obvious to say that different philosophical assumptions can produce different results. There are mainly three main assumptions in philosophical considerations. They are ontological, epistemological, and axiological assumptions.

Ontological Assumption

Ontology is a philosophical design that refers to the reality of being and the nature of reality (Guba & Lincoln, 1994). This assumption believes in reality which may be single or multiple. Single reality is the absolute or objective type of reality and multiple is the subjective one. I also believe that the "reality depends upon the time and context" (Pant, 2015, p. 34). The assumption of reality with multiple truths guided me in this research by establishing that reality is not a single absolute entity but rather depends upon time and context. So, I believe that the adaptation and acceptance of any process can be different from one to another. I have motivated my research participants to search for possible justifiable findings of the problems throughout the process of this research study. There are multiple approaches to implement my plan of action and uncovering the realities. This philosophical stance connects directly to the CPA learning approach in many ways such as individual adaptation, active meaning making, experience-based knowledge, active construction, etc. Hence, I have a subjective ontology in this research study.

Epistemological Assumption

Epistemology is the theory of knowledge that shows this study incorporates the subjective knowledge obtained from the participants. According to Mingers (2003), epistemology helps to recognize the different ways of knowing the world. It comes along with my study. In this assumption, I believe that the construction of knowledge is attached to the experiences of my participants. I have accepted their explorations throughout this study. In this process, my research plan upgrades social constructionist epistemology with the assumption that there is no absolute truth. I started this study with the assumption "*to establish how various claims for truth and reality become constructed in everyday life*" (Easterby et al., 2008, p. 93). I found that this assumption is the best fit for my research study.

In this research, knowledge is constructed through several key processes rooted in a social constructionist epistemology and an interpretive paradigm. It is fundamentally attached to the lived experiences of the participants rather than being an external, objective set of facts. Moreover, it is built through the explorations and inquiries of the participants. Knowledge is seen as a socially constructed reality within the interpretive framework. Hence, knowledge is not found, but is actively and socially created through the intersection of participant experiences, collaborative explorations, and the researcher's immersion in the classroom context

Axiological Assumption

The axiological assumption is a philosophical worldview that deals with the theory of value. This assumption incorporates ethics and aesthetics. Ethics investigates the moral standards that regulate right and good in individual and communal conduct whereas aesthetics concerns the concept of beauty and harmony (Zalta & Nodelman, 2022). My axiological assumption is value-laden, and hence I valued all participants as a researcher along with their experiences. While doing this research, the participants of this study became an integral part of guiding the action, reflect and make a difference. I valued the voice of each participant in this entire study through prolonged field engagement. So, in this study, value is a bonding of me with my research participants.

Research Paradigms

In this research, I have used two research paradigms, interpretative and criticalism that guide me in the investigation into the underlying factors contributing to this phenomenon. These paradigms shaped my ontological, epistemological and methodological perspectives to understand and address the research problem. Two main research paradigms that are able to guide this study are interpretivism and criticalism.

Interpretivism

In the case of interpretivism, Luitel (2009) focuses that every researcher should understand and investigate the real factors of the problem in society with the help of this research design. This paradigm helps me to know the phenomena from deep inside by learning to stand in the shoes of participants (Tayler & Medina, 2013). It produces the advocacy for subjective reality by rejecting the adaption of absolute or objective truth (Guba & Lincoln, 1989). This shows that interpretive researchers believe in socially constructed realities where a person should immerse himself in the active construction process of knowledge rather than perceiving reality as a passive-receptive process (Flick, 2004). As an interpretive researcher, I reconstructed the knowledge through a huge interaction that unfolds the realities of the participants.

Criticalism

The paradigm of criticalism helps me to direct myself and my practices as an auto-ethnographic researcher. In this type of research, the process of writing as inquiry (shared with the interpretive paradigm) has an added critical dimension and becomes a means of critical analysis and ideology critique of established policy and practice (Taylor & Medina, 2011). It also helps me to clarify the inhuman practices, inequalities, and social imbalances of society and advocate for social justice, and enabling ‘deep democracy’ (Kincheloe & McLaren, 2011). As this study consists of observation and reflection as the method of collecting data which has the quality of a critical paradigm, I have let my participants in a critical discussion through dialogues and dialectics (Guba & Lincoln 1994) to challenge their existing beliefs system and take for granted assumptions on their pedagogical practices and curriculum images. I encouraged them to reflect on their understanding critically during the research time. According to Taylor and Luitel (2012), I, as a critical researcher, strive to generate a professional praxis, that is, a practice aimed at social restructuring, at making a

difference by, for example, working with my critical reflection was addressed by this research study. While doing this, a critical paradigm helps me to present myself as a 'change agent' (Fullan, 2012).

Research Method

According to Denzin and Lincoln (1994), "Research method focuses on how we gain knowledge about the world" (p. 99). Moreover, Mingers (2003) identified that different methods can guide the action in the world. The purpose of this research study is to investigate the reason for declining engagement in learning mathematics at the secondary level. For this, I preferred to select the action-based research design where I have incorporated the participant's engagements.

Talking about the identification of my research problem, most of the students in the past took so much interest in learning mensuration. They engaged a lot in learning the topic but now I feel that I have given just the procedural and logarithmic knowledge of mensuration without connecting them with the real world. This made me so guilty nowadays. It's because I receive the knowledge in the same way from my teachers. Now, the time has changed. The students don't want rote memorization and procedural knowledge. It's the world of digitalization. Most of the students' demand concretization and visualization in study. They want their values and participation in their learning. This is good in today's life. So, the problem statement arises along with the research question. In this way, there is a need for action research in my context.

My research design is qualitative. Qualitative research deals with human behaviors, language, and experiences. Creswell (2013) states that "Qualitative research is best suited to address a research problem in which you do not know the variables and need to explore" (p. 16). It describes real-life human engagement by focusing on specific concepts. In my case, I dealt with textual information and hands-on activities. At first, I critically reflected on my own experiences and then I deal with my observations, findings and experiences. After that, I engaged in the teaching and learning process with my action plans by focusing on my research question.

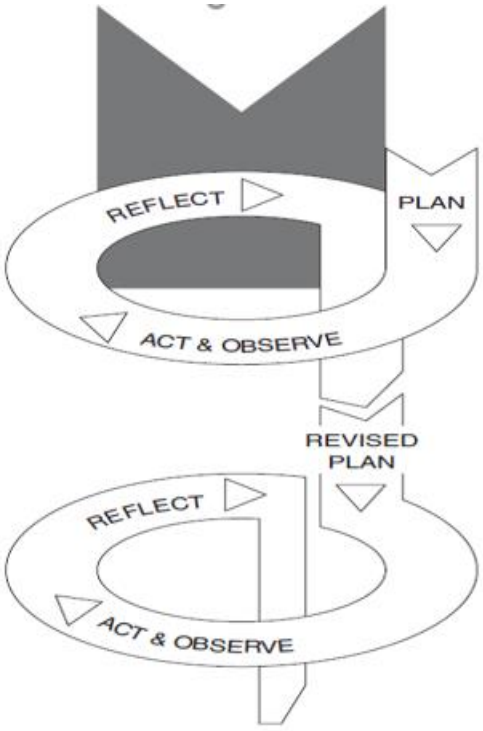
Research design is a plan and strategy of investigation to obtain answers to the research questions. It is the detailed plan of the investigation. It is the roadmap of the detailed procedures for analyzing the obtained data (Singh, 2008). My research problem is directly or indirectly related to the school and out-of-school factors. This research study is based on the information and engagements which I collect from the participants along with my self-inquiry and self-experience. To serve my research

purposes, I found action research is the best approach for me but I found that my experiences as a mathematics teacher for about 20 years also matter a lot in this study which might address through auto-ethnographic inquiry.

My action research plan went through five different components in a cycle. They are defining the problem, developing a plan to address the problem, acting which means implementing the plan and then observing which means paying attention and recording what is happening while collecting and generating evidence from data. At last, reflecting analyze, and evaluate outcomes by identifying ways to improve my practice. This cycle went on continuously till fifteen days of the action plan and helped me to prepare an effective finding of my research for the future.

Figure 1

Action research Spiral



(Kemmis & Mc Taggart, 1988)

The data collection process of this 15-day action research was a multifaceted and systematic process that aimed to capture the changes in student engagement and understanding using the Kemmis and McTaggart (1988) action research spiral (Planning, Action, Observation, and Reflection).

The initial, and most crucial, step in the action research spiral of Stephen Kemmis and Robin McTaggart is the Planning step. During this stage, the researcher looks for a problem, issue or area in need of improvement. The issue can be in

schools, classrooms, communities or the workplace. Once the problem is identified, the researcher takes the time to thoroughly investigate the situation and obtain background information. Objectives and goals are then well formulated; hence, the research has a proper direction. Planning also involves determining the action steps to take to resolve or fix the problem. The researcher chooses the techniques, tools and tactics for data collection, for example, interview, questionnaire, observation and test. Time, resources and participants are also taken into account in this phase. A good plan should be practical, structured and be able to be adapted as needed.

The Plan stage is critical as it gives them a roadmap for the entire action research process. Later stages, if not planned are confusing and unproductive. Planning is not a final step in action research, but can be modified when reflection and new understanding occurs. Therefore, the Plan stage provides the groundwork for improving and systematic investigation.

The second phase in the action research spiral is the “Act” phase. During this phase, the researcher implements the plan that they have prepared. Strategies, methods or interventions are practiced in a real-life situation as planned in the planning phase. The aim of this stage is to see if the action plan could have a positive effect on the problem/situation identified. For instance, a teacher can use new pedagogical techniques in the classroom, new group exercises or new pedagogical devices using technology in education. Likewise, an institution can implement new policies and/or procedures to enhance performance. At this time, the researcher is directly involved in the process and attentively implements the steps in the research plan.

It is the Act stage which is practical and action oriented, as it promotes change instead of just theoretical study of a problem. But the researcher needs to be flexible as may come unexpected during its implementation. Some modifications can be made, if necessary, but the general goals should be the same. This is a crucial stage as it is where ideas become reality. This enables the researcher to observe the plan in operation and if there are positive outcomes. Action learning is a valuable learning process, providing input into the next phase of observation and reflection in the research spiral.

The third phase of the action research spiral is “Observe”. During this phase, the researcher observes and documents the events observed when the action plan is carried out. Observation is required to assess and decide whether the actions are

having an effect or not. The researcher collects information in an organized, unbiased manner. It is important in this stage to gather data. This information can be gathered by observing the classroom, interviewing, administering questionnaires, reviewing student work, taking pictures, recording reports, field notes, or comments from students. The researcher considers both good and bad effects of the action. Reactions of the participants, their behavior and changes are also discussed.

Observation should be accurate, organized and unbiased in order for the findings to be reliable. The data gathered contributes to the research in order to know the effectiveness of the implemented action. It also assists in recognizing the challenges, unanticipated results, or opportunities for further development. The Observe stage is crucial as evidence for decision making. If the researcher doesn't observe, then he/she won't know if the action is successful or not. Reflection and future planning are based on the information that is gathered during this stage. So, seeing triggers action and further learning and development.

The last phase of the action research spiral is “Reflect”. Analysis and evaluation of the results of the observation stage is conducted by the researcher in this stage. Reflection will enable the researcher to gain insights into what went well, what went wrong and what needs improvement. The researcher reads through and compares the results with the goals of the research he has planned in the planning stage. Successes and weaknesses are noted as well as unexpected results. Reflection can also be a process of talking with the participants, colleagues or team members to seek other viewpoints and understanding. The researcher is aware of and reflective on the whole process and its effect.

This stage is crucial as it promotes learning from experience. Reflection assists the researcher in making decisions for the next steps. If that's the case, the strategy can be carried on or extended. If problems persist, another plan can be devised, which starts the planning, acting, observing, reflecting process again. Stephen Kemmis and Robin McTaggart state that action research is an ongoing spiral, and not a process. Thus, reflection is not the end of the research, but a new understanding and development. The Reflect stage is important so that action research is dynamic, practical, and continues to be a process of development.

The main data collection tools were pre-test and post-test, observation and field notes, reflexive journals, student reflections and feedback, and interviews. The entire process was guided by the DDLE method (Data collection, Discussion,

Literature justification, and Experience sharing) to ensure the analysis was grounded in both participant evidence and existing pedagogical theory.

The DDLE method is a framework that can be used as a guide for practitioners who are interested in using systematic inquiry to address problems in their work context. Data Collection phase is where data is collected directly from the field by the researcher. This includes the application of observation checklists, interviews, students' performances, or other quantitative tools. This is very important because it takes the inquiry process out of the realm of assumption and will give a real basis for the entire research process.

The Discussion phase is the next step in the research process after evidence is gathered, where a social and collaborative aspect of the research is added. The researcher does not make a sole analysis of the data; it is shared with stakeholders and/or peers to review findings. The dialogue can serve to question own beliefs and perceptions and can be used as a "triangulation" process to explore the data from multiple perspectives, thus enhancing the robustness of the interpretation of the data and inclusion of the multiple layers of the classroom or workplace.

In the Literature Justification phase, the gap between local practice and world knowledge is then filled. Existing research theories and peer-reviewed published research are used to identify the researcher's findings against the benchmarks. This is crucial to ensuring that the action research that is proposed is not simply a ‘band-aid' solution, but is based on a sound educational or psychological principle, so it has professional weight and credibility.

Lastly, the learning is shared and becomes a community asset in the Experience Sharing phase. This includes sharing results (successes and challenges) in a broader manner in workshops, reports or online. The researcher is part of a community of practice and sharing these experiences can elicit reflection on others' practices and create a culture of ongoing professional learning.

Research Site and Participants

I conducted this study in one of the private schools in the Kathmandu district. This study was conducted with the students of class X in Nov 24 – Dec 10, 2025 at the secondary level of the school. There were all together 24 students in the class. Among them, I have chosen six students as core participants.

Meaning Making from the Data

As a preliminary plan, I took a pre-test related to the mensuration topic and then I made an action plan of fifteen periods (one hour each) of class X from November 24 to December 10 to engage the students through concrete materials. After that, I observed the class daily and reflected on all the findings in a journal in written form. This helped me to collect the data and do the revised plan for the next day. Pseudo names were used instead of the participant's real names in the meaning making procedures. The data were refined and used for the further process. For the meaningful process of interpretation of gathered information, a social constructionist approach was used which is concerned with broad patterns of discourse that have used thematic style (King, 2012). The textual data was analyzed to find codes. Gibbs (2007) defines coding as identifying themes in data with labels categorizing the data into main themes. The coding made a sense to the study. The codes were then analyzed and interpreted under the themes with the supportive literature to understand the information they are reporting. Lastly, the core outcomes of the findings were generated and interpreted as per the conclusion of the research. The main process of data analysis and interpretation is explained by the DDLE (Data collection, Discussion, Literature justification, and Experience sharing) method.

Ensuring Quality Standards

The quality standard of any research is regarded as one of the important aspects of the research study. According to Coxon (2006), quality standards play a central role in all steps of the research process starting from the inception of research questions proceeding to the collection of data then analysis of data up to the interpretation of the findings in the process of qualitative methods. It is necessary to maintain the quality of the research study by considering the accurate, authentic, and truthful information produced by the knowledge of the study. Trustworthiness is taken into consideration as the quality standard of my research study.

To establish trustworthiness in a qualitative study one needs to establish four things credibility, transferability, dependability as well as conformability (Shenton, 2004). I, as a researcher, should have built a rapport and a prolonged engagement with the participants to maintain the credibility of the study Credibility refers to truth values which are set out to be enquired (Cohen et al., 2011). I spent enough prolonged time to collect the correct data or information which are related to my research project. I kept all the collected data safe. I maintained a thick description of the data

and findings as thick descriptions help people connect the results in their context (Guba & Lincoln, 1989). I have also maintained a thick description of the data and findings as thick descriptions help me connect the results to my context (Guba & Lincoln, 1989). This helped me with the findings of the study. Next, to maintain conformability I interpreted the result of this study based on the observed and collected data which are free from biases (Denzin & Lincoln, 2005). And then, to maintain dependability, I tried to maintain the consistency of the data and findings in this study. Finally, authenticity is the last quality standard under trustworthiness. Authenticity ensures that the findings are not only credible but also meaningful and relevant to the participant's contexts. So, these quality standards help me to think about the authentication of the information which is organized by the collected data in each day. For this, we should provide an equal opportunity for all the selected participants to share their outcomes. This can be achieved by creating an open and respectful environment in the classes. During interviews and focus groups, I asked several questions that encourage participants to think deeply about the factors affecting engagement in mathematics. Hence, authentic results and findings are also regarded as the important quality standard of the qualitative type of research study. The measures taken to ensure the most reliable interviewing, data collection and interpretation demonstrate trustworthiness (Dahal, 2023).

Ethical Consideration

"The term ethics usually refers to the moral principle and guiding conduct, which is held by a group or even a profession" (Wellington, 2015). As research is about discovering new knowledge or verifying existing knowledge, while conducting research this knowledge mustn't come at the expense of the welfare or rights of the people involved in the research. Some of the components that fall under ethical consideration are maintaining the privacy of every participant, informed consent, use of polite and appropriate language, respect for participants, etc. These ethics can provide a guideline or set of principles that support us in researching so that it is done justly and without harming anyone in the process. A researcher like me must ensure that the research is carried out in line with established ethical standards. Every step of the research project, from formulating the research question to publication, needs to be informed by ethics to ensure the integrity of the project. Some ethical considerations of my research work are explained below.

Informed Consent

Informed consent implies informed refusal “Those procedures for individuals to choose whether or not to participate in the research, once they have been told what it is about and what it requires, i.e., all those factors which might influence their decision.” (Diener, & Crandall, 1978, p. 75). So, I have protected and respected the right of self-determination and place some of the responsibility on my participant should anything go wrong in the research. Since the participants are below the age of 18, I have taken the consent from their parents in a written form.

Privacy

Privacy is a ‘basic human need’ (Caplan, 1982, p. 320). We should address the privacy of people and institutions, whoever and whatever gets involved in the research process. The greater the sensitivity of the information, the more safeguards are needed to protect the privacy of participants. So, I am totally careful in this matter for my research study.

Justice/Equity

The various individuals and groups that a researcher comes into contact with within the course of research should be treated equally. No one is unjustly favored or discriminated against. Respect for marginalized and deprived communities. The broader community should be supported. All the cultural norms and practices should be valued and respected. This is also observed critically during research time (National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research, 1979).

Chapter Summary

This study is an in-depth framework to improve Secondary mathematics in the context of Concrete-Pictorial-Abstract (CPA) approach and Qualitative action research approach in Nepal. It is based on Vygotsky's Social Constructivism which examines the Zone of Proximal Development (ZPD) and seeks to address a gap in the literature in a localized, practitioner-led intervention for mensuration. As a method, I used a subjective ontology, interpretive and critical paradigms, as well as an emphasis on participant experiences and active meaning making. During a 15-day intervention, I applied the action research spiral, and DDLE framework (Data collection, Discussion, Literature justification, Experience sharing) in a private school in

Kathmandu. The study results through an outcome of the pre/post tests and reflexive journals as study tools and the rigorous checking of ethical considerations and trustworthiness (credibility, transferability, dependability), are authentic, reflective, and context-specific for the unique challenges of the Nepalese educational landscape.

CHAPTER IV
PERCEIVING MATHEMATICS IN A CPA APPROACH AS A PRACTITIONER RESEARCHER

In this chapter, I collected data from fifteen days of fieldwork through action research. I have observed all the activities done by the participants and synthesized the major themes. In this research, I focus on increasing the understanding level of mensuration concepts (cones and square-based pyramid) through the CPA approach. This is an innovative type of student-centered pedagogical research. This study tries to identify the effectiveness of hands-on (concrete), digital (Pictorial) and collaborative (abstract) ways of learning methods. Moreover, this research also helps to analyses and interpret the traditional type of lecture approach by teachers with the modern type of engaged learning approach i.e. CPA approach by the students themselves. The reflection given by each student daily during the class time is also one of the major data tools for the research that helps to identify the gaps between the teachers and students in teaching-learning activities.

I reviewed the journey of my action research as a researcher and tried to find out the effectiveness of the CPA approach in teaching mathematics. Similarly, I have discussed a lot with my key participants (focused students) to draw the actual conclusion and explain the important themes and ideas through the discussion and collected data on different topics. I also summarized the supporting thoughts about this learning approach.

The main objectives of this research are to know the prior knowledge about the content of mensuration, determine the importance of lab-based activities like constructing 3D models with clay, papers, etc. with their results, understanding the clear role of digital tools like GeoGebra through dynamic visualizations and compare the teaching techniques for diverse learners. In addition, the objectives are also to measure the progress through a post-test mirroring the pre-test by analyzing score changes and identifying the challenges raised in the process.

Participants' Description

The research participants were the heterogeneous students of Grade X from one of the institutional schools of Kathmandu Valley. Most of the students were not interested in learning mathematics. So, motivation to learn mathematics was one of

the major challenges in the class as only some of the students were regular in their mathematics assignments and interactive in the class. A short description of some key participants (with their pseudo names) of my research is presented below:

Ramu

Ramu stood out among the 15-day mensuration action research participants through his broad subject knowledge combined with his analytical thinking mindset and his objective view on teaching approach innovation. Right from the first day, he showed remarkable mastery of the subject by scoring the top total of 19 out of 20 points in the pre-test assessment. His outstanding achievement in the testing phase proved his excellent grasp of cone and pyramid concepts thus making him a top student in the classroom. During his reflection, he proudly declared that the subject materials came to him easily. His statement combined both beliefs in his knowledge strength and high-performance aspirations.

As Ramu participated in both hands-on and digital learning activities he showed his strong interest in practical learning experiences. During the laboratory experience on Days 2 through 6 he built 3D models with clay and cardboard tools and worked with GeoGebra digital software. During the third day, he expressed enthusiasm about collaborative learning whereby he noticed "*creativity and innovation*" running throughout the activities and motivated that this method should be implemented as a daily feature across all subjects. His thoughts showed he preferred active learning methods instead of memorization because the visual approach made learning more understanding (Day 2).

Ramu exhibited a sense of curiosity as he learned GeoGebra software during the days 7 through 9. He admitted that the application of ICT in the classroom would simplify the process of learning about area and volume concepts since GeoGebra allowed rotating 3D models dynamically to gain a better idea of the geometric relationships. He praised Day 8 learning on August 8 by saying that the class was more interesting and newer than usual because he demonstrated a desire to use technology in the educational practices.

Ramu combined his creative commitment to innovation with realistic input from his work perspective. The pre-test assessments revealed that he had reservations about excessive dependency on classroom laboratories and digital resources as they might develop unfavorable studying practices that confuse students and create lazy

behaviors. His careful analysis showed a skilled perspective on education which recommended both modern educational techniques alongside essential academic principles.

Ramu failed to participate in the Day 13 post-test assessment thus creating an incomplete record of his quantitative educational achievement. His development manifested through the qualitative findings obtained from reflection reports and questionnaires. Through laboratory experiments and GeoGebra usage, he demonstrated enhanced capacity to correctly use formulas and made "*noticeable progress*" in problem-solving according to his Day 15 final questionnaire results. His group work ethic became evident because he gave high scores to group assignments and generated innovative observations which he shared in our discussions.

Ramus' path included phases when he paused to think about himself. Traditional lectures lost his interest since he preferred learning methods that required active student involvement (Day 4). His feedback included several recommendations such as using GeoGebra as an ICT tool effectively to prevent passive learning (Day 9).

Although Ramus' absence in the post-test evaluation limited direct comparison with other students, he successfully demonstrated proactive behavior along with reflective learning by combining innovation with traditional methods. Students viewed him as a learning model because his educational success merged with his ability to evaluate and change things in the classroom. His absence from the post -test evaluation did not allow direct assessment of his development but his innovative and team-oriented feedback brought unique value to the study which demonstrated students' impact on developing strong pedagogical methods. The educational experience of him demonstrates how education reaches its full potential when students channel their curiosity through careful judgment and when they combine advanced practices with core educational principles.

Gyanu

Gyanu demonstrated a path of increasing competency together with growing tenacity which manifested during her 15 days of action research about mensuration. she started as a beginner who battled basic concepts until she evolved into an independent learner managing subjects and teaching methods. The beginning of her educational adventure brought numerous substantial challenges to her path. On Day 1,

she achieved 3 out of 20 marks which placed her among the underperforming students in the class. According to her reflection, she felt anxious because they lacked knowledge about the exam which caused poor performance. The poor results from the first assessment showed that she did not feel confident about the topic at that time. The poor mark reflected her inability to recall mathematical formulas while failing to apply the Pythagorean theorem to cone and pyramid figures.

During practical events, Gyanu exhibited dramatic changes in her commitment level to the lesson. During 3rd day she had success in a collaborative team activity by making 3D clay and cardboard models. She found both the experience and hands-on learning methods entertaining but highlighted that material scarcity created difficulties for her. Her joint work assignments showed she worked well with others despite any limitations affecting their workflow. She worked on paper models during the 5th day yet faced challenges from the lack of glue and scissors which she overcame before sharing "*We had to wait for materials but ended up finishing the project.*"

Our lesson turned significant after students experienced GeoGebra software during days 6 through 8. Gyanu started away from the digital tools until she finally accepted their value. The sixth day's work involved cone and pyramid net building which brought her both difficulty and contentment because she enjoyed seeing flat nets develop into three-dimensional shapes. She showed positive emotions toward the GeoGebra dynamic features by day 8 yet indicated she needed extra time for individual practice since "*I wish we could use GeoGebra on our devices to strengthen our knowledge longer.*" The habit she developed with technology became more comfortable through her hands-on activities.

The problem-solving skills of Gyanu improved steadily. On day 10, Gyanu found the answer verification through digital GeoGebra questions to be more convenient. The worksheet on day 12 contained thirteen tasks and she handled most of them through peer collaboration. She noted improvement since her earlier habit of blanking questions because now she attempts challenges that were too difficult before. She made substantial academic growth in the post-test phase when she scored 14 marks out of 20 whereas she scored just 3 marks in the pre-test period. She observed that the current questions seemed straightforward because we kept practicing extensively. She openly acknowledged that advanced-level questions still posed

problems demonstrating her understanding of both new and previous gaps in her knowledge.

Gyanu frequently provided feedback which showed she preferred learning by doing rather than staying passive during classwork. She expressed textbook practice to be less interesting than modeling activities during standard school sessions. She pointed out that insufficient materials created obstacles that must be resolved before running future activities. On the 14th day, she shared her thoughts about how concept review felt good but personal involvement in learning activities provided her with a deeper understanding.

Gyanu gave herself high marks regarding teamwork in addition to solving problems correctly after participating in lab work because she found the activities helped her remember formulas better (Day 15 questionnaire). Despite these ongoing difficulties she faced in understanding mensuration concepts she understood that more practice would help her improve. Blended learning is evidenced by the educational approaches through her experiences and the full potential they can realize. The phenomena demonstrate how her progress progressed through nervousness into quantifiable achievements thanks to consistent efforts together with practical activities combined with tailored teaching methods. Her attendance in labs and online classes at her school has helped her develop the sense of competence and confidence through occasional disconnection to her regular classes and the inconvenience of logistics.

Gyanu is the one that gives the essential information in her actual performance assessment that displays commitment and her inclination towards practical education to develop inclusive teaching strategies that are student-centered. Advances she has made in her mensuration research indicate that she has a very good groundwork that will propel her success in the subject in the future since she is curious as well as persevering in her work.

Syamu

Syamu took part in the 15 days action research on mensuration which demonstrated his educational progress through thoughtful examination and showed his preference for hands-on learning experiences. Traditional pedagogy caused him to struggle in the beginning yet his engagement with hands-on learning and digital resources enabled him to gain 19 out of 20 points on his post-test while his pre-test

score had been only 7 out of 20. Student-centered teaching approaches can transform students as his experience shows.

Syamu started the research noticeably dissatisfied with conventional classroom instructions at the beginning. The initial assessment showed his score at 7 out of 20 along with his observation that "*Most teachers do not understand the feelings of students.*" Everyone inside the classroom always experienced boredom during class time. The evaluation exposed his negative experience with passive teaching methods based on textbooks. His problems at the start of the session with both formula and Pythagorean theorem applications to cones and pyramids demonstrated a lack of basic knowledge.

Syamu was most interested in the course during the experimental laboratory sessions that occurred on Days 2 to 6. The 2nd day experience of constructing skeletal models provided an exciting experience that minimized his feeling of time constraint when performing math. Day 3 Artificial 3D models created using clay and cardboard helped students collaborate and solve problems. He realized that teamwork became essential after completing these activities but material shortages sometimes reduced his interest. On day 5, he demonstrated persistence through the building process as he waited for materials to complete the paper models saying "*We managed through the wait.*"

Acceptance of GeoGebra software occurred during days 6 through 9 and students experienced a mix of curiosity and frustration. On the first day of net construction (Day 6), Syamu admitted complete helplessness which subsided when the teacher provided instructional support. During Day 8 he complimented the dynamic features of the software yet requested personalized attention from his teacher for each device since it would help him memorize information better. He displayed an interest in having more control in digital learning while technical obstacles prevented him from becoming fully active in the process.

Syamu reached his highest point of task achievement on day 13 by scoring 19 out of 20 on the post-test. He mentioned his improved performance by noting that the second round of questions was simpler since they had previously encountered them. He maintained his intense dislike for conventional academic examinations such as tests. During this learning experience, he demonstrated why he avoided standard evaluations even though he had mastered the subject material because he preferred practical applications instead of traditional assessments.

Syamu consistently critiqued resource inequities. During day 14 the observer presented a GeoGebra slideshow yet he felt sad because he could not show it since he lacked home devices. His thoughts demonstrated how economic gaps produce challenges for students to participate. The day 15 questionnaire from the end of the study renewed his complaints about the scarcity of resources and recommended that schools should ensure all students receive equal educational tools.

Syamu expressed through his feedback that blended learning has proven effective for his learning. He established that hands-on practice resulted in his best achievement because it helped him visualize shapes through GeoGebra. He noted down continuing obstacles with abstract connections while advocating for "*additional experimental time as part of the curriculum.*" Through his learning experience, he discovered that autonomous discovery alongside practical work suited him best but standard rules made him uncomfortable.

Syamu successfully developed into an outstanding student after teachers adapted their teaching methods towards engaging activities thus showing personalized interactive education techniques work to release student potential. His critique of traditional approaches to education and his focus on equal learning materials and his capacity to surmount obstacles are useful lessons to teachers. His test scores indicated mastery but his assessment preparation difficulties indicate the need to have wide institutional changes in inclusive education to accommodate all students. Teaching students in ways that focus on their needs demonstrates how disheartened students can achieve learning success according to testimony of him.

Byanju

During 15 days research on mensuration, Byanju demonstrated both an active intellectual mindset along with team-building qualities merged with mature levels of confidence and humility. From his beginning as an outstanding student, he used practical learning methods alongside digital instruction to master the concepts and campaigned for fair resource distribution. He demonstrated his status as a conscientious learner through his reflections and academic results when combined with his leadership in peer presentations while expressing critique toward systemic flaws.

Byanju entered the challenge as one of the best students who scored 17 of 20 points in their initial assessment (Day 1). At the early stage of the project, he provided

evidence showing he grasped fundamental principles including the Pythagorean Theorem together with geometric relational concepts. He acknowledged his difficulty in visualizing three-dimensional structures even though he excelled at solving problems because visualizing slant heights or nets was particularly challenging for him. Understanding his strengths propelled him to show great interest in laboratory work.

The level of participation at Byanju reached its highest point during the times dedicated to laboratory work (Days 2 to 6). He played a leadership role during the pyramid construction task on Day 3 by guiding his team though he remained light-hearted when he stated their results were "*the worst but he had given his best*." Teamwork together with his humble nature distinguished his performance while he highlighted that hands-on learning activities transformed abstract formulas into tangible realities. We waited patiently for materials during paper model building on day 5 because it proved challenging for everyone to wait even though practical work was still enjoyable according to his later remark.

During days 7 through 9, Byanju demonstrated his capability to transition into using GeoGebra software. The software tools fascinated him because he understood them straight away and praised the three-dimensional dynamic rotations as revolutionary and Space understanding became easier because of them. During day 8, he demonstrated enhanced self-confidence by conducting a peer discussion about pyramid construction in GeoGebra which was supported by positive feedback for his well-explained procedures. According to his self-assessment, he prefers learning through hands-on activities instead of observing demonstrations by others.

Byanju demonstrated his best leadership skills on day 14 during his student-led presentation about core concepts from the research study. He started the presentation feeling afraid but he managed to overcome his fear and recognized in hindsight that "*Presenting demonstrated to me which information I truly had learned.*" Participants in his peer group recognized the value of his slideshow content because it helped them memorize mathematical formulas.

Byanju scored only 14 out of 20 points on day 13 due to his excessive confidence in answering familiar questions. Higher-order problems challenged him during his self-assessment because they demanded extensive reasoning steps. He confessed that he moved too fast through challenging questions and this experience proved the requirement for additional practice with advanced applications.

The mentioned feedback from Byanju pointed to extensive challenges in the healthcare system. Material shortages affected his participation so he told schools to "*invest in better tools which allow everybody to take part fully.*" At the midpoint mark of day 14 technical bugs interfered with his presentation until he stated: "*Not everyone should have to deal with this problem since practice with GeoGebra is not feasible for home.*" His comments established him as an outspoken champion of fair distribution of resources.

Byanju reported good performance in collaborative tasks as well as problem-solving accuracy through his lab experiences which made formulas unforgettable during the final questionnaire (Day 15). He continued to face problems with abstract geometric concepts while requesting further experimental time. The end of his experience taught him mathematical discovery involves more than solving problems it demands formulating more insightful inquiries.

Byanju demonstrated how aptitude combines effort and advocacy throughout his action research process. He demonstrated excellent academic abilities but his decreasing scores on the post-test highlighted his weakness when under stress even though he was an accomplished student. Throughout his research, he exposed resource-related challenges which he associated with obstacles in the path of inclusive education structures. Through his participation, he transitioned beyond learner status to become a reflective researcher in pedagogical studies while he demonstrated how the study intended to develop both competency and analytical reasoning skills. Through his life work, he showed how education flourishes when personal development unites with community activism due to his ability to combine curiosity and compassion.

Sanu

Sanu spent 15 days participating in an action research study on mensuration which led to her gradual confidence building alongside her positive views on interactive learning. She overcame her initial intimidation with abstract geometric ideas during guided practical activities and computer-based instruction to reach a post-test result of 9 out of 20 after starting with 5 out of 20 on the pre-test. She presents the problematic sides of learning new teaching methods and its successful steps through sincere analyses and strong will. The commencement of the investigation project by her also began with clear indications of discomfort.

Sanu who scored 5 out of 20 points on day 1 to show his difficulties with memorization and calculation-related abilities including problems in slant height and volume. Her reflection showed her unease because she worried about taking the exam. During exams, she struggled to recover information needed for the problems. The student preferred giving tests with advanced notification instead of impromptu assessments because such structure allowed her time to prepare.

The engagement level of Sanu became more intense throughout laboratory sessions spanning days 2 to 6. She struggled with building the pyramid during the task but succeeded in constructing the cone and explained that she found making the cone easier than the pyramid. "*I'm glad I tried.*" She replied. She kept striving because she remained determined to reach her targets even when they proved challenging. She managed material shortages during day 5 to build paper models which she said gave her pride despite the delayed time for glue and scissors.

Sanu experienced initial uncertainty when GeoGebra software was presented during days 6 to 9 of the programs. She faced difficulties in net creation on day 6 although she understood how visualizing mathematical formulas became possible through this educational component. During day 8 she improved her confidence through GeoGebra model manipulation which helped her better understand slant height. Her thought process indicated she moved from fearfulness to carefully optimistic feelings regarding using technology for educational purposes.

Sanu scored 9 out of 20 points on her day 13 post-test which demonstrated gradual improvement. Her scoring improvement came from "*practicing formulas through models and software*" yet she still felt uncertain about multi-step problems. Her evaluation of progress displayed a mix of confidence and awareness of remaining uncertainties because she had tried all questions yet still doubted specific solutions.

Sanu thrived in collaborative settings. She viewed a GeoGebra presentation from a peer as helpful in reviewing mathematical formulas although she wished for more opportunity to create her content on day 14. She concluded that working with others helped her feel more comfortable approaching friends with questions (Day 15 questionnaire response). She criticized schools for inadequate resource provision as she believed all students needed enough materials to stay included.

Throughout our meetings, Sanu consistently pointed to the requirement of practice focused on specific subjects. She placed hands-on activities at the top to gain a better understanding yet wanted more opportunities to repeat tasks until she fully

comprehended them. The worksheet completion on day 12 made her realize she no longer skipped difficult questions because she attempted all problems now regardless of their outcome.

Patient teaching methods under student-focused instruction helped Sanu achieve a complete educational transformation. The gradual development of the student to controlled confidence is evidence that students studying abstract subjects need to employ visual and tactile techniques. Though her test scores did not improve significantly, she proved through reflection that she was more prepared to approach challenging tasks and seek help when necessary. The case of her shows that she persevered due to her persistence in learning about mensuration despite her gradual improvement as she struggled to secure equal access to education resources. Her perseverance now makes her an advocate of practical learning. The way she progresses demonstrates to teachers that learning occurs on a non-linear path as each minor achievement leads to upcoming academic achievements.

Haku

During the 15 days of action research on mensuration, Haku evolved through a complete behavioral change from being an uninterested math doubter to an enthusiastic student participant. Student attitudes and educational achievements underwent substantial improvement according to data which showed 14 out of 20 changes from the pre-test to post-test results. He entered the research period showing visible discomfort. On day one he scored 2 out of 20 on the pre-test which demonstrated his insufficient knowledge and his marked dislike for math classes. The student admitted through reflection that he did not like mathematics. Much to my disappointment I received that unexpected test. A tiny glimmer of interest developed from his miserable experience. The planned curriculum for upcoming classes has sparked his hope that math might lose its boring character.

The attention of Haku to the class content changed when moving into laboratory work between days 2 through 6. Through his day 3 project which required 3D model constructions from clay and cardboard, he found himself capable of creative problem-solving. Despite their unexecuted plans, the challenge was intriguing according to him and better than traditional textbooks. He used humor to manage his frustration during day 5 when he had to work with unglued paper by describing paper folding as an interesting puzzle activity. Through his observations,

he started to feel better about math because the experience was different from anything he had experienced before.

The interest of Haku in the subject advanced when GeoGebra software integration occurred during days 6 through 9. According to him the dynamic visuals in the software revealed slant height understanding and net relationships in a novel way. According to him, "*We need to try it ourselves*." Student-driven active exploration emerged as a key preference according to the received feedback and kept appearing throughout his comments.

The 16 out of 20 marks that Haku achieved in his post-test demonstrated his academic development. His accomplishment came from "*practicing with models and seeing formulas in action*" he declared. The reflection showed that he now displayed increased confidence because he used to pass over questions. The new me attempts all problems regardless of whether I have full confidence in them. He understood that abstract relationships needed more experimental time in the laboratory.

After learning new concepts Haku became active in the promotion of equal educational resource opportunities. In his perspective of laboratory work, he pointed out the lack of materials expressing "*How can we learn when we are struggling to get scissors?*" His day 15 questionnaire demanded that schools allocate funding for equipment that would provide students with equal opportunities in their learning.

Throughout his educational journey, Haku displayed mental strength and personal identification changes. His path demonstrates how teaching through practice transforms hopeless negotiation with mathematics into a meaningful and purposeful understanding of mathematical formulas. Through his evaluation of traditional education with his analysis of unequal resource distribution he has established himself as an educated participant in educational studies.

The examples taught by Haku showcase how student-directed teaching methods bring profound academic outcomes. His remarkable intellectual progress alongside transitioning from uninterested compliance to active learner supports how interactive teaching methods bring back intrinsic motivation and develop student-driven learning practice. The educational transformation of him shows that students who receive agency and exploration tools can overcome abstract learning difficulties and resource limitations to create new relationships with education. The real achievement that he has left behind surpasses his test results because he developed the belief that everyone can master math which is no longer a terrifying force.

Besides these key participants of the research, the short overview and key reflections of some other participants with their scores of pre- and post-tests are listed as follows:

Table 1

My Observation and Reflection with Pre and Post Test

Participants	Pre-test (20)	Post-test (20)	Key observation and reflection
Participant 1	8	16	In day 2, participant found visualization through concrete materials very fruitful.
Participant 2	4	12	Participant found the learning approach motivated to do such questions in examinations.
Participant 3	17	19	Participant appreciated the new approach using objects for memorizing formulas.
Participant 4	2	10	Participant found the post-test similar to the pre-test and was able to solve many questions this time.
Participant 5	2	11	Participant found learning GeoGebra fun and effective and became confident about formulas/answers because of understanding the topic.
Participant 6	5	14	Participant found that the visual representation made the formula clearer
Participant 7	12	18	Participant noted that in the pre-test, they just applied formulas, but in the post-test, they applied them with understanding.
Participant 8	17	19	In day 2, participant was previously struggling to remember relations but found them easy to understand and remember after the visual class.

At last, the transition to the CPA approach, incorporating hands-on models and digital visualization tools like GeoGebra, led to noticeable improvements in confidence and quantitative achievement for the majority of participants, particularly those who initially scored lowest. They tended to prefer active learning techniques to

passive traditional classes, but the problem of resource shortage and the necessity of individualized digital practice was always mentioned.

Analysis of Field Research

This is the section where I enlisted the major findings of the research study. I listed the ideas through observation, collected data, reflexive journal, interactions and interviews with participants. They all help me to give the conclusions of the research. The collected data strongly supports the major ideas and findings of different areas. They were more articulated using interpretation and analysis. In this regard, seven major ideas as themes have been discussed and collected data has been used as evidence.

CPA Approach as a Transformative Power

On the second class of my action research dated 9th December 2025, I observed minutely and introduced the topic by relating it to the questions of a pre-test. On that day, I entered with some of the concrete materials like skeletal models (made by chop sticks) of triangular-based and square-based pyramids, solid objects of cones and pyramids made up of glass and plastic and one set of models that describes the concepts of Pythagoras theorem (equation). While entering the class, the students were surprised and excited. I displayed the solid objects and began to describe the faces, bases and vertices of the cone and pyramid. Then, we have the discussion section with one another. One below average student said, "*Learning with concrete materials made easy. It helped us a lot.*" This makes me happy and realized that the concrete materials are essential positive transformative tools for the learning activity in teaching learning process While taking the reflection on that very day, another student replied, "*I was struggling to remember the relation but now it feels easy to remember and understand the relation about slant height, base and vertical height.*" Then I asked to him, "*What is the reason behind this?*" Again, he replied, "*The discussion of teaching in the class with the help of physical and visual representation was quite helpful. It made the classroom environment much more engaging and effective. I have had always problem in keeping formula in my mind. After the class, I found the formula to be clearer than before.*"

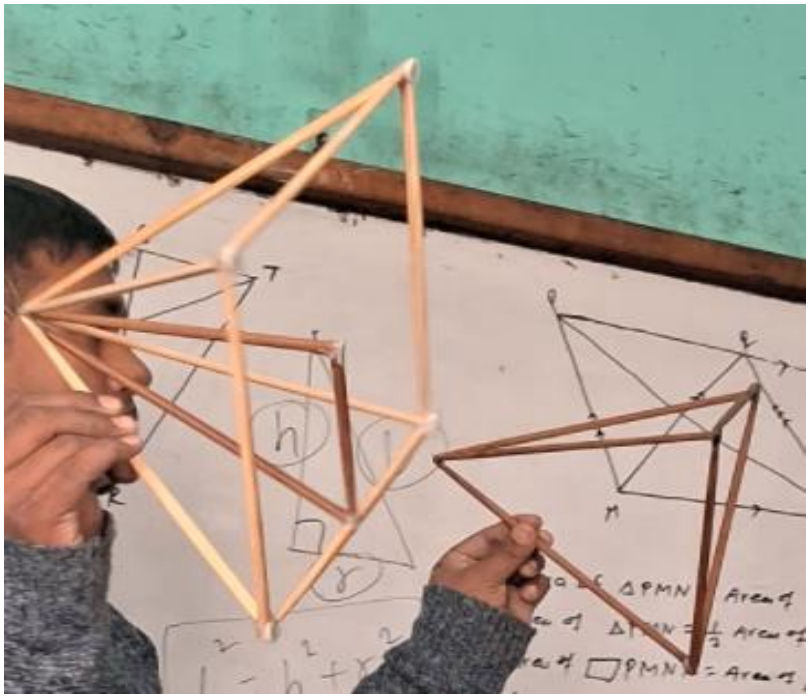
Figure 2

Concrete Material 1

In the third class of my action research dated 10th December 2025, I observed minutely the collaborative work done by the students (participants). The class was conducted in the math lab. They were so glad and thrilled to do the work. I saw that they were doing their hands-on activities with a great interest. In a group, I observed that some are engaged in making cones and pyramids from clay and some were busy in making the solids from card board.

Figure 3

Concrete Material 2



It's good to observe their activities. While talking about the feelings and opinions, one of the key students said, "*Today is an amazing day as we experienced both teamwork and hard work. Today's class was full of creativity and innovation"* Another added, *"Exciting experience. There was a feeling of having less time in mathematics for the first time."*

At the end of the activity of that day, each group showcased their models, which turned out to be exceptional examples of creativity and teamwork.

Figure 4

Use of Cardboard

Figure 5

Use of Clay

Later on, on 12th December 2025, I made the students (participants) to make the pyramid and cone through the sheet of paper. This session also gave valuable learning experience for both students and me.

On 15th December 2025, I visited the digital lab with the students in the seventh class of my action research. In the digital lab, I explained about what to do

and what not to do in the lab. The dynamic visualizations in GeoGebra were enjoyed by many participants, as it was easier to memorize and comprehend concepts.

Figure 6

Logo of GeoGebra

The environment of the classroom was nice in this time as every student was looking with so enjoying and silently. They loved the software very much because I asked some questions related to GeoGebra and one of them answered "*I love this software very much, I am enjoying it a lot, I am having fun in constructing the pyramid, etc*." I helped them through the way of constructing nets of both square-based pyramids and cones in the GeoGebra. In the discussion session, Haku said, "*In this session, I learned to make 3D objects like pyramid and cone with their nets in the GeoGebra screen. It was entertaining and engaging*" I discovered that teaching using technology, especially GeoGebra, can greatly improve the engagement and conceptual learning of the student using the pictorial method. This course was another step towards the incorporation of technology in mathematics teaching, and learning became effective and enjoyable.

Figure 7

Cone in GeoGebra

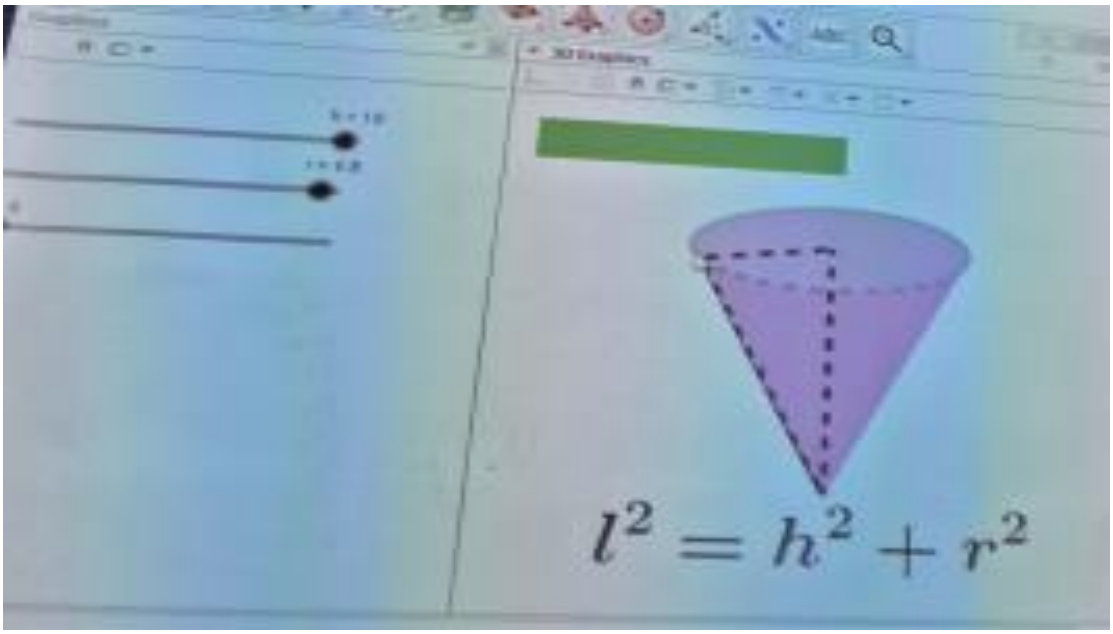
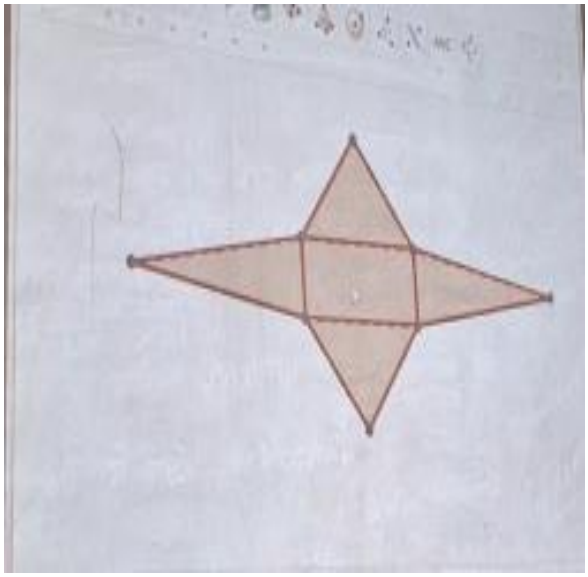


Figure 8

Net of Pyramid in GeoGebra



I displayed the new question in just one click in the readymade GeoGebra file, and most of the students were surprised in the generating new questions with changes in values. For my easiness, I chose some of the relatable old dynamic files of GeoGebra made at the time of lockdown. I found some of the students were so engaged in solving the problem quickly. They were competing with each other to find the answers. I enjoyed their participative activities. This is possibly because their knowledge about this subject is improved.

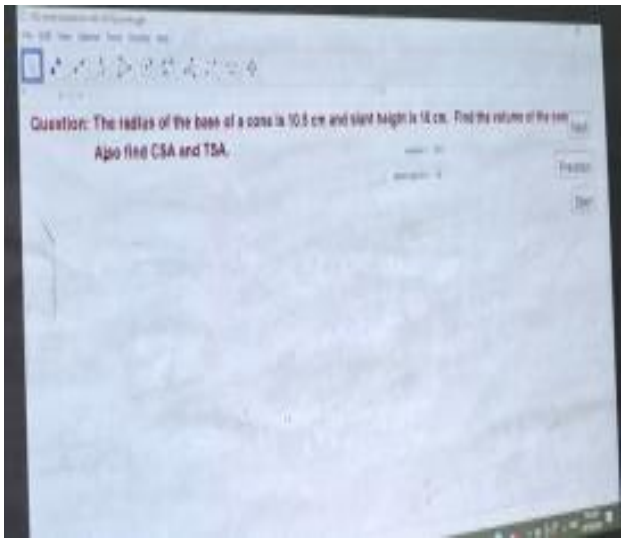
Figure 9

Student in Laptop

Regarding the views by the participants, one said, "*We solved different numerical problems generated by GeoGebra in our copy. It was interesting.*" Another added, "*We solved all the questions generated by GeoGebra in our copy. It was good and helpful class, so, it was good and helpful with examinations as well.*" And the other respondent replied, *"The same old same lesson today as doing it in the set book. A difference is that the questions were produced on the GeoGebra on the screen."* The session was a success because it incorporated the use of digital tools and mathematical problem solving and created an interactive and engaging learning environment. The active involvement of the student and the positive feedback are the indicators that the given approach was effective to promote the knowledge and memorization of mathematical ideas in the student.

Figure 10

Questions in GeoGebra



Through this, I changed my plan of action research to concrete, pictorial, and lastly an abstract in 15 days. This experience guided me in refining my approach to create a more holistic and inclusive learning environment in future classes because I felt that the session was successful in achieving its objectives, the incident with the principal and the feedback from students emphasized the need to strike a balance between discipline, engagement and diverse teaching methodologies with a transformative power.

The action research done in the classroom shows using the CPA approach significantly increases student's participation, improves their understanding and gives them more confidence to learn concepts connected to cones and square-based pyramids. By using hands-on materials and digital tools, the students gained a lot from the approach and their performance improved greatly. Students were given solid models of cones and pyramids, and models of Pythagoras theorem. When students saw the models, it immediately brought out a sense of surprise and excitement in them. While observing models, students gave the lesson full attention which was obvious from their expressions. Watching the demonstrations, they were able to grasp what slant height, vertical height and radius meant. Students note that using this visualization helps them learn in a more effective way. One student mentioned that it was convenient to make the data visual through models. In the same way, other students believe that understanding how the Pythagoras formula appears in various cases will stick with them for a long time. After observing the demonstration, the student who once had problems remembering the relation now sees it as "easy to understand and remember." Gyanu suggested that using real examples would support their ability to remember the Pythagoras equation "$h^2 = p^2 + b^2$" in a right-angled triangle. This helped students begin to understand the relationships they noticed in the concrete materials.

During Day 3, students collaborated in groups to make models of cones and square-based pyramids out of clay and cardboard in the math lab. They were keen on working and were especially attentive to it. The teacher noted that they were cooperating with one another while completing their assignments. Students mentioned that the class was enjoyable, tireless and sparked their creativity and innovation. They believed that these activities allowed them to understand the parts of cones and pyramids by experimenting themselves. Before, Gyanu struggled with making a pyramid, yet she eventually felt very happy and glad to be involved in such activities. During this construction phase, they learned new things about design and had so much more fun with math which they used to avoid.

From there, the focus was placed on using GeoGebra for abstract and graphical representations. Day 7's introduction to GeoGebra was a "new and thrilling subject" for students. The 3D perspectives and animations of various objects and their nets were received with lots of excitement and applause. After using the visuals, students felt more confident with difficult topics and that remembering information became less difficult. Ramu thought that learning this would make it possible to understand concepts related to subjects like area and volume. One of the students believed the class to be both entertaining and more effective. Another student believed that the formula was simpler to comprehend after the visual representation. It was also evident that students were more concentrated on their studies and learned the subjects more with visualizations.

On day 8, we all worked with GeoGebra to make 3D shapes and their nets and enjoyed it. They noted that what they learned was better and happened in a different and effective way. Here, what students learned as '3D geometry and nets' were now turned into digital ways they could interact with.

The digital stage shifted to focusing on finding solutions to dynamic tasks. For Days 9 and 10, I showed dynamic questions and answers about surface area and volume using GeoGebra. The students were fascinated by how the software found new challenges for them. They made an effort to address these issues. At this point, students could use the book to match their answers with the instructor's steps. Students mentioned that this process was interesting, gave them new information and helped them understand better using GeoGebra. Haku believed that this class was more effective than learning by using pens and pencils. She mentioned that completing certain sample problems made her understanding of the subject easier and

made it possible to check the answers “instantly.” It moved from learning visuals and theory towards applying formulas and solving problems.

During Days 11 and 12, students performed and applied their new understanding from the course. Students worked on classic textbook questions and a list of practice problems. They seemed much more confident and found it easier to solve various problems. Most students said they answered many questions easily, found them straightforward and no longer had difficulties as they used to. It was much simpler to use formulas. Their confidence in the class was due to work they did before and the understanding they already had about the topic. Because she understood the concept, one of the students was sure about the formula and the answer. It was during this level that they demonstrated that they had become better at solving common mathematical problems over time.

The transformation can be seen through the change in pre-test and post-test results. During the pre-test, it was discovered that many students had little previous knowledge Australian classified education system, which means a vast majority of students demonstrated notable improvement after taking the post-test with the same questions. One student started by answering a few questions and later solved all the problems easily. A Student’s score went up from 2 to 11. Gyanu increased her score from 9 to 18 and another Syamu went up from 8 to 16. According to the teacher, there was an obvious improvement in student’s confidence and skills in solving problems. In one of the student’s opinions, during the pre-test, students simply depended on formulas, but afterward, they were able to solve problems through understanding. Furthermore, the survey suggests that students had better grasp and usage of the concepts after the program.

All in all, the use of various teaching methods from beginning with concrete models and activities, through pictorial digital tools and ending with using such understanding to solve various problems, truly changed the teaching process. Using these new ways of teaching solved students’ early difficulties, increased their motivation, improved recall of the basics and helped them feel more self-assured about dealing with math problems. Transformation in learning happens when students start worrying, have low scores and then feel excited, understand the topics and get higher scores.

Revitalized Engagement in the Learning

On the second day of the class, I explained the relationship between the lengths used in the objects. I specially explained about different Pythagoras relations (In cone: $l^2 = h^2 + r^2$, in the square-based pyramid: $l^2 = h^2 + (\frac{a}{2})^2$, $e^2 = l^2 + (\frac{a}{2})^2$, $e^2 = h^2 + (\frac{d}{2})^2$. After explaining all, I asked for some content related to the topic of that class. They gave the correct answers. It made me happy. It was the time for discussion. One of the participants shared his voice as "*I gain much knowledge. Sir taught us about the relation of slant height, base and vertical height. I was struggling to remember the relation but now it feels easy to remember and understand the relation.*" Actually, the voice emitter was an average non-concentration type of student in a class. His voice supports that the concrete method of learning revitalized the engagement in the learning. Another below average participant raised her voice as:

> *The discussion of teaching in the class with the help of physical and visual representation was quite helpful. It made the classroom environment much more engaging and effective. I have had always problem in keeping formula in my mind. After the class, I found the formula to be clearer than before.*

In the third class of my action research dated 10th December 2025, I observed minutely the collaborative work done by the students (participants). The class is conducted in the math lab. They did the arts and crafts with clay and card board. During the class, I saw one of the average students was helping everyone in making concrete materials in his group. This also symbolize the engagement procedure. A Sanu said, "*I could not make pyramid by myself. It was quite difficult to make pyramid but was very easy to make a cone. I am feeling glad to involve in such activities.*"

Figure 11

Concrete Models

Similarly, in the fifth class of my action research dated 12th December 2025, I made the students (participants) to engage in the hands-on activities. They had fun on doing those activities. One key participant view was that the class was really interesting to do the task. He got to know somehow new things too. One more participant added that they got a lot of idea about how 3D shapes are made up of. The activity helped to increase their level of study through engagement. In another day, the students made the nets of cone and pyramid together where I acted as the facilitator to them. While making nets, one of the passive students said, "*It was an excellent class for developing concepts.*" as he was also in the deep engagement.

Therefore, the student engagement is one of the important aspects of effective learning which directly influence the student's understanding with motivation and overall achievement in mathematics. If students engage actively and participate in teaching and learning activity by thinking creatively with a deeper conceptual understanding, they move beyond the rote memorization.

In the case of my action research, the initial stage involves hands-on activities with physical and tangible objects. It renders the learning interesting and entertaining. The students were very excited in focusing on making different models of pyramids and cones from clay and cardboard. They played with manipulatives and strengthen their core understanding as they did the real example of learning by doing.

Figure 12

Students Participating in Different Mode

Figure 13

Models of Cones and Square Based Pyramids Through Hands-on Activities

In the transitional stage, students engage in the image representations in digital tools. This engagement in the students helps to visualize concepts which help in serving as a bridge from concrete to abstract. Actually, students observe different dynamic 3D models and nets through GeoGebra software. Most of the students express their feelings as the software was new and thrilling, interesting, and effective. The visualization in the screen helped them to understand the complex topic in a simple way.

In the final stage, students apply formula in the abstract way. They did some of the numerical problems as worksheet in their exercise copy. They found this stage engaging because it allowed them to use formulae and check their solutions instantly and worked on using the formulae correctly which enhance their confidence in the great way.

CPA Approach as a Student Learning Agency

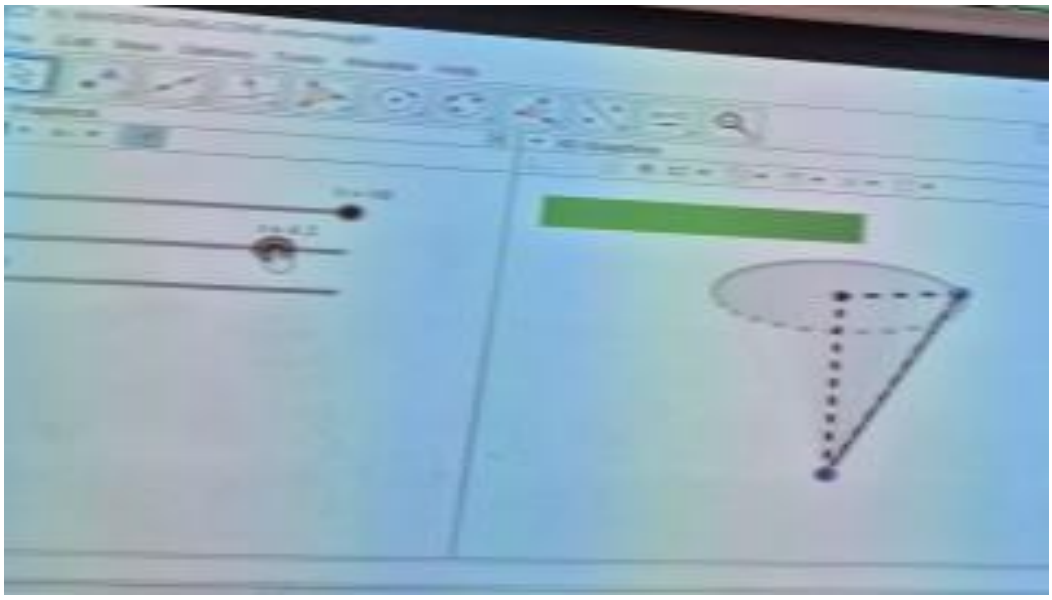
As observed in the entire action research on mensuration on Concrete-Pictural-Abstract (CPA) approach, student learning agency significantly changed by shifting them from passive recipients of knowledge to active, engaged and self-directed learners. This positive transformative impact was clearly seen through student's performance, their activeness, confidence and growing critical awareness throughout the study.

Initially, many students were noticeably disinterested in mathematics resulting a few numbers of students complete their assignments. The reason may be due to traditional lecture-based teaching methods which may make them bored and disengaged. One of the students explicitly stated their feelings as only the textbook learning was boring and expressing hope that the new approach would be interesting. Ramu, being a top performer, found traditional lectures uninteresting and preferred active student involvement. On the same note, another important Gyanu said that, most teachers are not aware of how students feel and that he would like to visit lab to learn the fundamentals and he was looking forward to a lab-based method. At the start, a few of the students were initially having difficulties with memorizing formulas and being nervous about unexpected exams. This early disconnection revealed a distinct necessity of new pedagogical approaches that would enable students and provide them with greater control over the learning process.

Then, the concrete stage of CPA approach immediately sparked student engagement and the sense of agency because of the hands-on activities. When I introduced the skeletal models and solid objects of pyramids and cones, students were excited and surprised with focusing on full concentration on the demonstrations. They visualized some basic concepts like slant height, vertical height and radius which help them to learn more effectively and remember the Pythagoras formula for a long time. One of the students, who previously struggled to retain formulas, found them clearer after the visual and physical demonstrations.

Figure 14

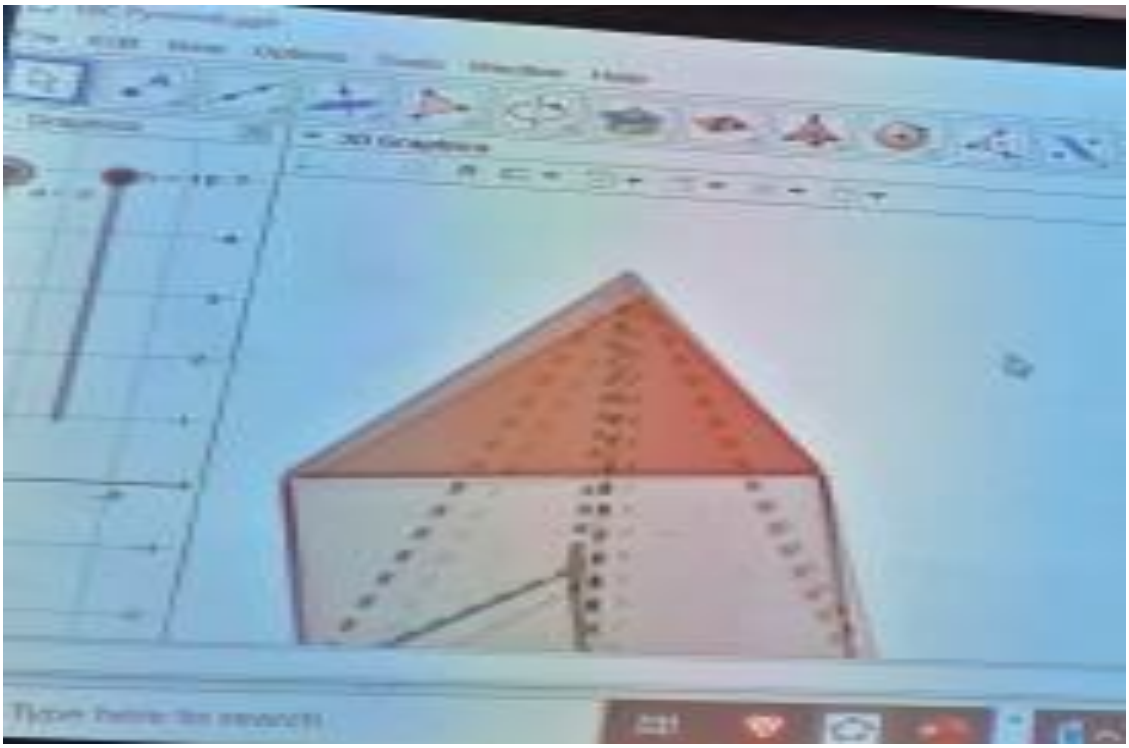
GeoGebra File 1



A significant change in student agency was observed during the collaborative 3D model construction on Day 3, where students used clay and cardboard. They were so excited and happy to do the work by actively building models and assisting each other. This experience can be explained as "*learning by doing by themselves*". Some key participants enjoyed with their creativity and innovation whereas some found these hands-on activities was entertaining and exciting experience. Even we faced material shortages on Day 5, some students overcame the challenges to finish their paper models. This firsthand experience enabled the students to learn the components of pyramids and cones by trying it themselves to reinforce their theoretical knowledge.

Figure 15

GeoGebra File 2



A digital software, GeoGebra, in a pictorial stage, yet again increased the agency of students more by offering dynamic visualization. They also mentioned enthusiasm and cheering of the 3D views and animation, where they felt more confident with challenging matters and where they could easily recall all the information. Among others, one of the respondents said that GeoGebra would simplify the explanation of such notions as area and volume, which demonstrates his immediate understanding of how the software could be used in more profound study.

Likewise, another respondent also had fun with the online classes and thought they were more efficient.

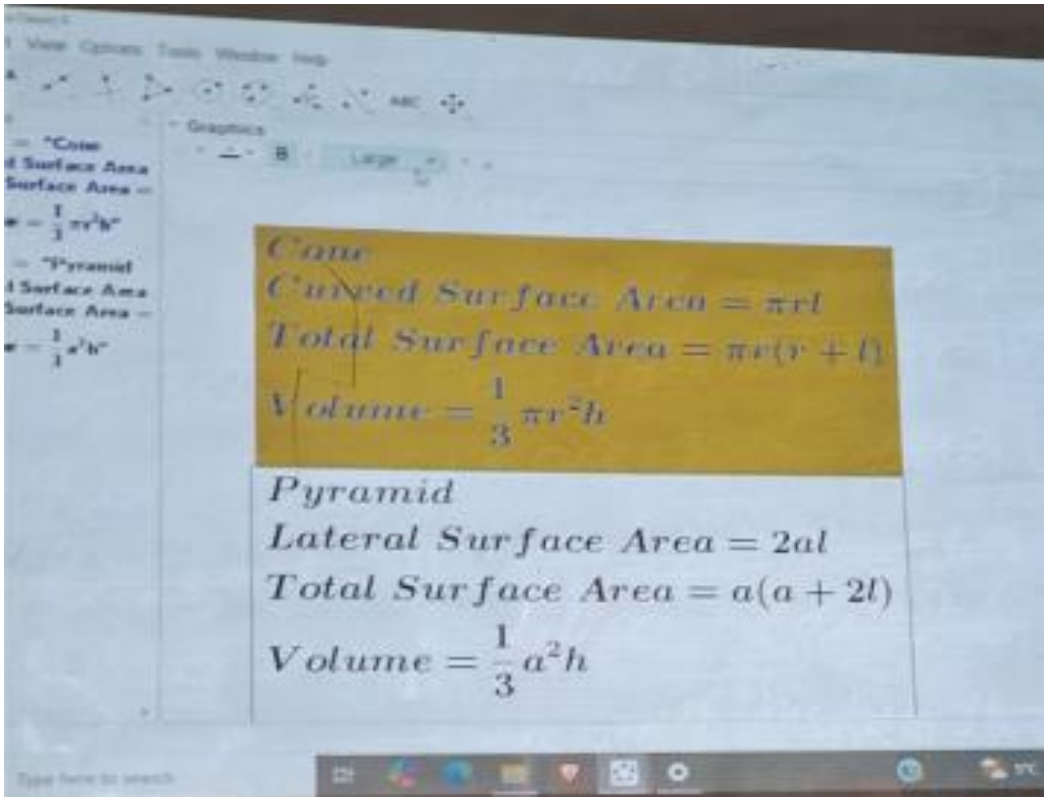
On Day 8, the learners were actively involved in the creation of 3D shapes and nets with the help of GeoGebra. A number of students soon mastered the tools and subsequently went on to show greater self-confidence by facilitating a discussion with peers on how to build pyramids and cones in GeoGebra. Among the participants, there was the observation that GeoGebra was a new experience that was also preferable to writing on paper, as it indicated that they prefer teaching and learning via an interactive digital platform. This close engagement with technology enabled students to manipulate and learn the abstract concepts in a better way.

On Day 10, it was observed that, when solving dynamic questions that were created by GeoGebra, students were very active, even competing to get the answers. This demonstrates that the students moved towards the application of formulae and problem-solving since their agency was expressed through problem-solving, self-evaluation and conceptual clarity. They actively used the software and check their answers instantly which demonstrate self-assessment skills and taking ownership of their learning. One of the students clearly said that this method was more effective than learning by using pens and pencils and found easier to check answers instantly. Most of them expressed immense satisfaction on doing the solutions correctly with confidence.

Students exhibited agency with traditional worksheet sessions on Day 11 and 12. They confidently solved problems, finding them easier due to prior hands-on and digital experiences. The majority of the students noted that the subject matter now was not challenging. This process of critical thinking and good conceptual knowledge was depicted when part of the students identified an error in the worksheet with a lot of confidence and called an error LSA, which was supposed to be CSA; which represented a cone. This critical thinking and the desire to know better highlighted how their agency as critical learners were being increasingly active. Furthermore, this improved agency was also proved by the post-test results, as the majority of the students demonstrated the significant improvement of scores under the influence of. Not by memorizing, but by much practice and knowledge.

Figure 16

Formula in GeoGebra



Technology in CPA Approach as Intermediary to Abstract Understanding

The application of technology particularly GeoGebra software became a major factor in addressing the gap between the abstract approach of understanding and the concrete approach. This technological integration mainly worked in the Pictorial level of the CPA framework which allowed dynamic visualization and interaction which transformed complex mathematical concepts to reach reachable and interesting forms. It also sought to find out the purpose of digital tools using active visualizations.

Day 7 came with the introduction of GeoGebra with great excitement in the learning arena. The application enables the students to view the 3D objects on the screen as they rotate. This feature of software helps to clarify the abstract notions like Pythagorean relationships within pyramids and cones. Regarded the participants voice, one student noted, “GeoGebra made me easier to recall the formula” and another student said, “*I found better to understand about the difference between slant height and vertical height in pyramids and cones.*” The software's ability to animate nets flattening into 2D and then re-forming into 3D structures captivated the students to make easier for them to grasp the relationship between 2D nets and their corresponding 3D forms.

Figure 17

Presentation on GeoGebra 1

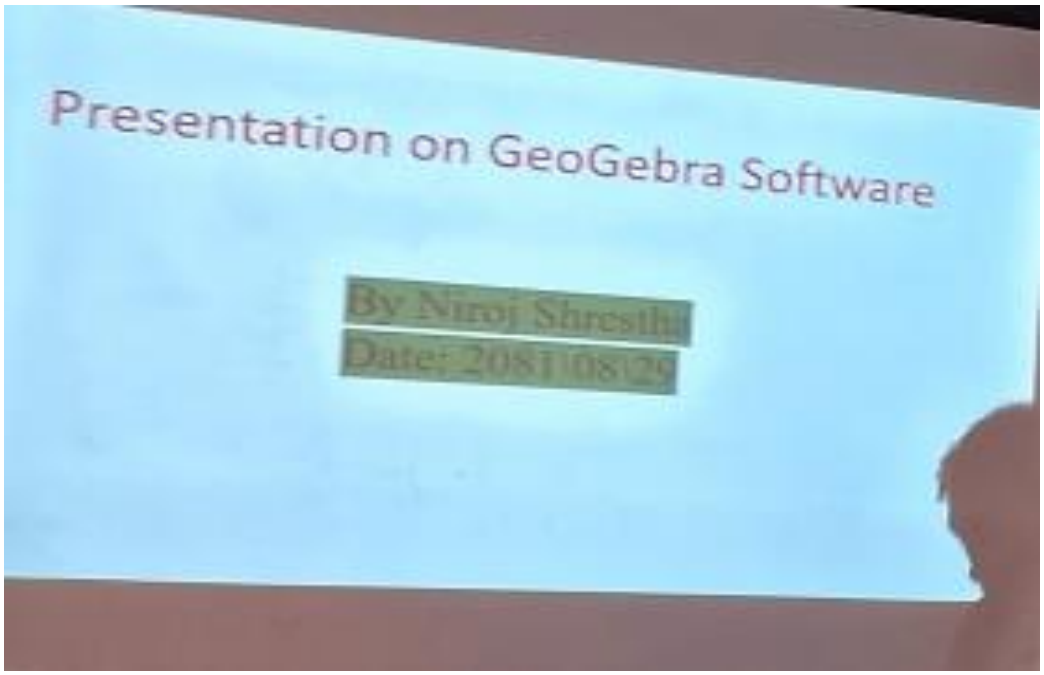
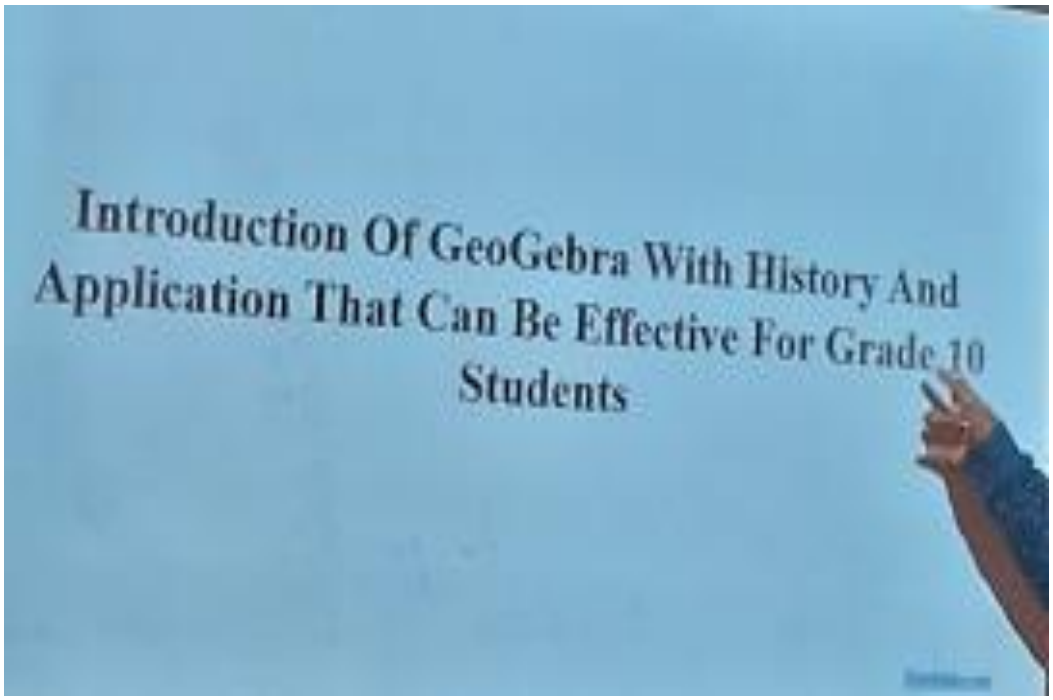


Figure 18

Presentation on GeoGebra 2



In addition to the passive viewing, technology provided an opportunity to engage in the process of construction and exploration through an increased level of

abstraction understanding. On Day 8, students were active in constructing pyramids based on squares and conical objects in GeoGebra of 3D graphic view. This practical electronic building enabled them to memorize the properties and relations of these forms.

The observation showed that students loved the class very much and reported as enjoying a lot while constructing the 3D objects. They realized that the technology made the concept clearer. I think that the digital creation of nets also enhanced their knowledge. This dynamic manipulation shifted learning to a tangible, concrete level to a pictorial, interactive level, which led to abstract reasoning.

Similarly, GeoGebra was utilized to present dynamic mathematical problems related to surface area and volume. The software has ability to generate new questions in one click which also provide the instant answer for verification. This made the students highly engaging. Later on, this phase shifted learning from learning visuals and theory towards applying formulas and solving problems. This feedback mechanism gave them instant feedback that made them confident in the correct application of abstract formulas.

Figure 19

Participants in Doing Class Assignments

Although technology is proved to be a powerful bridge, certain technical challenges were also noted. Resource accessibility was a consistent concern, with one key participant who expressed somehow disappointment over lacking personal devices for practice. He exposed his feeling with better if they did all the activities individually in the lab. Technology, in a sense, served as a powerful pictorial bridge,

which dynamically visualized and allowed interaction with abstract concepts, which greatly contributed to student understanding and engagement in the CPA framework.

CPA Approach as a Collaborative Learning and Peer-Driven Growth

The Social Constructivism theory of Vygotsky helps justify the transition to student-centered learning by emphasizing that learning is most effective when students engage with More Knowledgeable Other (MKO) and learn within their Zone of Proximal Development (ZPD) through collaborative scaffolding. Similarly, Finley and Reason (2016) argues that when learners engage together in complex problems, they benefit significantly from peer support, gain a deeper understanding, and experience increased motivation. So, the CPA approach in the action research significantly promoted collaborative learning and peer-driven growth among students by changing traditional teacher-centered instruction to the student-centered methodology with engagement. This pedagogical change in the study encouraged participants to participate actively, discussion and mutual support by leading to increase understanding and confidence in the given concepts.

The initial concrete stage of the approach was foundation to establish a collaborative learning environment. On day 3, in the context of concrete approach, students worked in groups in the math lab to construct 3D models of pyramids and cones by using clay and cardboard. Observations showed that students were cooperating with one another in making models. Some students were assisting in cutting the models and some were pasting. It was showing the genuine teamwork in the learning. The key students took the leadership role during the pyramid and cone construction guiding their team with kind-hearted attitude. While making paper models in day 5, there was some shortage in materials but they waited for them and ended up with finishing the project. This hands-on engagement, despite logistical challenges, deeply embedded collaborative habits.

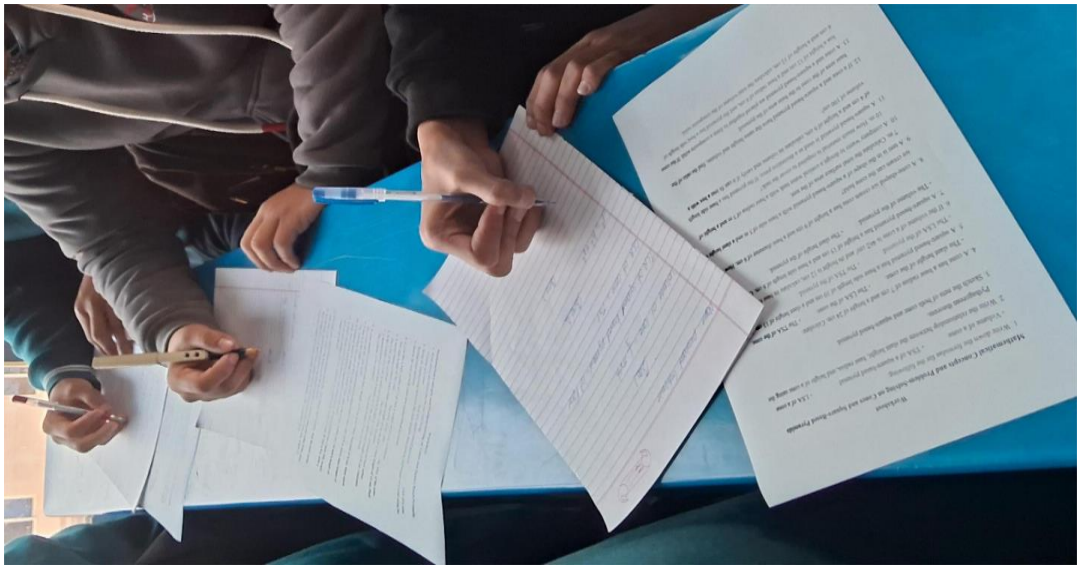
As the research transitioned to more abstract and application-based tasks, peer interaction continued to drive learning. On day 10, students solved some dynamic questions generated by GeoGebra in their copies actively, competing with each other to find the answers. The explanation of the process on screen further facilitated peer learning. In day 12, while working on a comprehensive worksheet, students were explicitly encouraged to share their understanding with their bench partner. At the end of the class, I asked, "*How is the today's class? Dear students!"* One of the key

participants replied proudly, "*I have successfully handled most of the problems through peer collaboration.*" Student's collective ability to identify an error in the worksheet (LSA vs CSA) underscored their heightened critical thinking and mutual learning.

Another powerful presentation by the students on day 14 proved the growth in peer driven activities. This activity helped their peers to revise the topic and recall mathematical formulas. Some students specifically focused on the value of their presentation's presentation in adding the revision and recall. Moreover, one of the participated students observed the presentation as a reflection of the immersive participation of students and their enhanced learning. So, this approach successfully created a dynamic learning environment where students actively learned with and from each other, leading to profound conceptual understanding and enhanced interpersonal skills.

Figure 20

Students Solving Problems of Worksheet



Challenges of Resource Accessibility

Warschauer (2004) on the Digital Divide provides a theoretical framework for understanding why student disengagement occurs when there is unequal access to digital tools. This supports the "*Pictorial*" stage findings where students expressed "*sadness*" and a sense of "*inequity*" because they lacked the home devices necessary to practice with GeoGebra. Moreover, an empirical review cites Poudel (2017), who found that external factors (such as socio-economic status and home environment)

play a more significant role in poor mathematics performance than internal school factors. Challenges related to resource accessibility emerged as a significant theme throughout the research time which create the negative impact and implementation in the effectiveness in the CPA approach. Some of the major challenges are shortage of physical materials during hands-on activities and limitations of digital tools, etc.

During the concrete stage of learning, students frequently encountered with the scarcity of materials. This affected the engagement in learning. For example, some of the students mentioned that the material scarcity created difficulties for their group. This problem was even more experienced in the activities involving paper models due to a lack of scissors and glue sticks. These shortages not only consumed valuable class time but also sometimes reduced student's interest and effective participation. This slowed down our work as the students had to wait for their turn to use the limited resources. This delay in the activities made some frustration to the students. One student mentioned in her reflection note as "*The insufficient supply of items made it difficult to complete her origami.*" Similarly, I as an instructor, I also felt difficult in conducting such hands-on activities. Moreover, there is the challenge in the sufficient budget by the teacher or school for many times.

In the pictorial stage, I introduced digital tools in the lab where we faced hurdles in technical and resource related field. Specially, in day 8, the class encountered with an initial technical issue with the projector causing delay in starting the class. While conducting the class, one of the key participants expressed, "*I have a strong desire for individualized attention and devices for effective utilization of GeoGebra software*" He added, "*Sir should teach us individually in every device so that we can remember it for a long time.*" Another student Ramu also mentioned disappointment in excessive dependency on classroom laboratories and digital resources. According to him, "*The excessive dependency in lab and digital resources may create unfavorable practices with lazy behaviors.*" This arises a tension between the benefits of technology and the practical challenges of equitable access and effective integration. Another key participant noted the boarder issue of resource inequity. In this case, he commented "*Sir, all the students were not capable of having smart device at their homes.*"

The problem in the device led students to critique in the provision of materials. As a suggestion, one of the key participants prayed and give the suggestion as "*I wish insufficient materials will be resolved in the coming future.*" Similarly, another

participant expressed as the suggestion, "*The difficulty in learning due to shortage in materials can be resolved by demanding to form funding to purchase essential materials.*" Another participant added on the same issue as "*School should invest in better tools which allow everybody to take part fully.*" These insights from many students proves that they express the importance of adequate resources for making inclusive and effective learning environment critically where all students engage with modern pedagogical methods. Despite the observed improvements in understanding and engagement, the research indicates that resource accessibility remains a fundamental barrier that needs to be addressed for optimal learning outcomes.

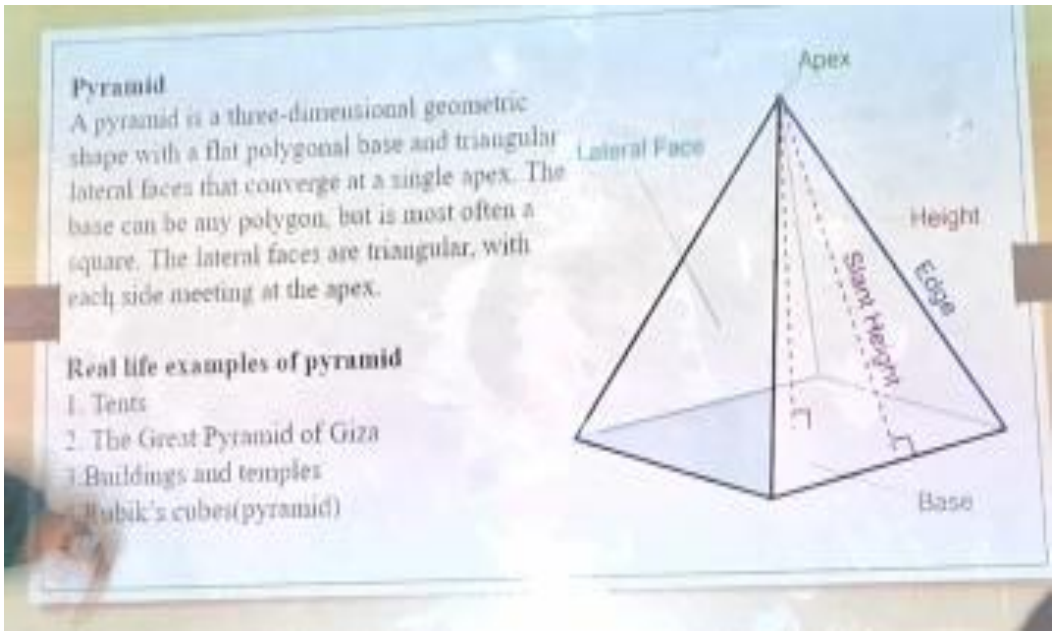
CPA Approach for Equity Learning

The CPA approach of my research is designed not only to enhance the understanding and engagement with the critical lens, but also to examine and address issues of equity in mathematical learning. With the help of different instructions, diverse learners achieve certain opportunities from which they can implement and expose their existing disparities about resource accessibility and individual learning preferences.

At first, the approach demonstrated significant gap between prior knowledge and smart engagement among learners with different existing academic backgrounds. Some students who previously struggled or showed disinterest in mathematics that can be easily observed during pre-test time had also demonstrated significant and notable positive changes and attitude. The first stage i.e. concrete stage transferred the abstract contents to the tangible realities. For instance, one of the key participants found the methods so entertaining while another found constructing models are intriguing and better than traditional textbooks. Similarly, another participant, who often had trouble in remembering formula, found the physical as well as visual representation in class was helpful, more engaging and effective. This active engagement allowed students to build confidence and develop more intuitive grasp of concepts like slant height (l), vertical height (h) and radius (r) or length of the base (a).

Figure 21

Participant's Presentation Slide



The implementation of the research talks about the equality of opportunity. During the hands-on activity class, students frequently encountered the scarcity of the materials such as glue sticks, scissors, cardboard, etc. The shortages led to delays and frustration among the students but they showed the integrity because they performed all the tasks with collaboration in a group. In the case of digital (pictural) stage, we generally felt the issue in equity learning because some of the participants lacked home devices to practice GeoGebra or prepare presentations. One of the students said, "*Everyone is not capable of practicing with GeoGebra at their home.*" The final questionnaire data also revealed that 18 out of 23 students experienced technical difficulties with devices or software. The various insights suggest that the CPA approach is beneficial to the learners as it fulfills the individual needs by providing an equitable access to diverse learning experiences.

Analytical Study of Pre and Post Test Results

The pre-Test was a surprise test of marks on the first day to check the understanding level of the students. One of the talented students in the class scored 19 out of 20 while many students scored single digit with lowest score 2. This initial assessment confirmed that many students possessed little prior knowledge, struggled with memorization and often relied simply on formulas. Similarly, the post-test was conducted again unexpectedly on Day 13 using the exact same set of 20-mark

questions. The result showed lots of improvement across the class. The average mark was also increased with high percentage. Students found the questions simple and were confident in addressing the problems with high scores of 19 marks being achieved by three participants. There was a noticeable improvement in the class. Regarding the tests, one key participant said, "*Today was again surprise post-test for us. But the questions were easy as we had already solved such questions in previous classes. I felt very easy this time."* Another added, "*Today, we gave the post-test. Previously in the pre-test, I could solve only 4 or 5 questions but this time I felt a very big improvement as I could solve all the questions without any difficulty."* Similarly, another participant said, "*We gave a post-test in today's class to compare our understanding with the pre-test. Previously, we tried to solve the problems just by applying formulas but now we apply by understanding. I am able to solve the questions."* Likewise, Syanu said, "*The questions were so easy. The questions that I could not do in the last test were also solved this time."*

As a comparative insight, the results show a major significant academic development for the majority of participants, moving from passive learning to enhanced conceptual comprehension. Many students who initially scored very low showed remarkable gains by adding double digits in singles of previous pre-test score. The observation showed that the students progressed qualitatively from attempting to solve problems just by applying rote formulas in the pre-test to solving them through deeper understanding in the post-test.

In conclusion, the CPA approach is a powerful tool for promoting engagement and understanding, particularly for the students who might traditionally disengage from mathematics. However, achieving true equity in learning requires addressing the logistical and resource-related challenges that hinder the full participation. Moreover, it is essential to ensure that every learner feels equally supported and engaged by understanding and observing the diverse learning preferences of students with an innovative pedagogical framework. Therefore, this approach not only serves through the teaching method but also reflects and improves the equitable learning opportunities.

Voice of Students as Reflection and Feedback

` Based on the student's reflections and feedback collected across the research period, their voices regarding the mensuration study using the CPA approach are categorized below:

Understanding Mensuration

The students continuously commented on their improved understanding of cones and square-based pyramids with the geometrical relationship among their components.

Voice no. 1: "*I am clear about the right-angled triangle, cone and pyramid now. It was pleasant to be visualized practically.*"

Voice no. 2: *"I could obtain a clear idea of how Pythagoras formula is achieved in other situations."*

Voice no. 3: *"I found the formula to be clearer than before."*

Voice no. 4: *Today we were taught to make the nets of pyramid and cone."*

Voice no. 5*: "The questions were not complicated and were easy to solve. It was due to good understanding of the topic."*

Applying the Role of CPA Approach

Students showed a clear preference for hands-on, interactive learning and expressed criticism toward traditional passive methods like textbook learning, lecture method, etc.

Voice no. 1: "*Most of the teachers do not understand the feelings of students. We were always bored by learning in the classroom.*"

Voice no. 2: *"We wanted to go lab to understand the basic concepts."*

Voice no. 3: *"We will be getting knowledge in new and different ways by using objects. I like this approach to learning."*

Voice no. 4: *"Learning with tangible materials was easy. It assisted us a lot."*

Voice no. 5*: "The discussion of teaching in the class with the help of physical and visual representation was quite helpful."*

Voice no. 6: "*We heard about GeoGebra. It was also the good time learning the net of cone and pyramid by visualizing them on the screen.*"

Voice no. 7: "*Today's class is better than paper pencil class*."

Challenged Faced

This includes difficulties related to test-taking anxiety, intellectual comprehension hurdles or emotional disengagement at the time of research in action.

Voice no. 1: "*I felt nervous to deliver my understanding in the class on the screen.*"

Voice no. 2: *"Today's class is somehow boring because we are not engaged in any activity rather just listening and listening."*

Voice no. 3: *"Worksheet was boring. I only like doing projects as we did in previous classes like making the cones and pyramids, etc."*

Overall Experience

This section includes the student's general enjoyment, satisfaction and the novelty of the action research classes.

Voice no. 1: "*Overall, it sounds interesting what we are going to do in the coming days.*"

Voice no. 2: *"The classes were quite helpful and entertaining."*

Voice no. 3: "*Most of the classes were very exciting, I gain much knowledge."*

Voice no. 4: *"Exciting experience. There was a feeling of having less time in mathematics for the first time."*

Voice no. 5*: "It was very good experience with my friends."*

Voice no. 6: "Most of the classes *were interesting and newer than before.*"

Voice no. 7: "*If we were taught like this since childhood, we all would love mathematics subject*."

Voice no. 8: "*I felt so easy because the previous effective classes taken by us helped me a lot*."

Improvements Suggested

Students provided specific recommendations regarding materials, personalized instruction and the general application of the methodology.

Voice no. 1: "*The technique of the new approach might bring bad habits to the students. Engaging in different lab activities and digital devices can make the students less interested in reading books. Less work can make students lazy too.*"

Voice no. 2: *"Today's class was full of creativity and innovation. I think it should be applied daily in other classes as well."*

Voice no. 3: "*The system of this kind of teaching needs to be have more and more in the upcoming days. We should have to focus on this type of learning."*

Voice no. 4: *"I am not happy with the class because sir should teach us individually in every device so that we can remember it for a long time."*
Voice no. 5*: "I am disappointed with the class because in my opinion I felt better if we did all the activities individually in the lab."*

Impact of the CPA approach

The study defines the quantifiable or demonstrable positive changes achieved through the research, such as improved confidence, successful problem-solving and enhanced retention.

Voice no. 1: "*I was struggling to remember the relation but now it feels easy to remember and understand the relation.*"
Voice no. 2: *"This will surely help our formula memorizing power."*
Voice no. 3: "*It seems that I don't need to read all those Pythagoras relations because I already know the relation and formulae by seeing surrounding."*
Voice no. 4: *"I observe clearly that they have built their confidence in solving the questions in the copy."*
Voice no. 5*: "I felt a very big improvement as I could solve all the questions without any difficulty."*
Voice no. 6: "*The questions that I could not do in the last test were also solved this time.*"
Voice no. 7: "*Previously, we tried to solve the problems just by applying formulas but now we apply by understanding*."
Voice no. 8: "*Practical performance on certain questions made my learning easier and interesting. This made me check my solutions instantly due to the digital equipment used in the class*."
Voice no. 9: "*The class was informative and made better to know and understand through GeoGebra.*"

Word of Appreciation

Different positive response was delivered as statements that includes thanks or praise to the teacher researcher.

Voice no. 1: "*I will fully support my teacher in these special classes.*"
Voice no. 2: *"Sir helped me step by step and I made the nets in a fine way."*
Voice no. 3: "*I was confused in two HA type of questions. I asked to the teacher and managed to solve them properly."*

Voice no. 4: *"I found some questions hard but due to the help of sir, I could finally solve each and every question at last."*

Voice no. 5*: "The way he presented was very nice."*

Challenges Encountered

Some of the challenges regarding logistical and external obstacles like materials, time and technical failures were encountered at the time of class conduction.

Voice no. 1: "*We had to wait for materials but ended up finishing the project.*"

Voice no. 2: *"There was a shortage of some materials such as scissors, glue, etc."*

Voice no. 3: "*Due to the lack of glue and other materials it was frustrating."*

Voice no. 4: *"I got bored at the last because of the insufficient supply of materials like scissors, glue, etc."*

Voice no. 5*: "We need to make the cone and pyramid but we have to wait for materials."*

Voice no. 6: "*I am unsatisfied with the lesser number of scissors provided to us because I need to wait for some minutes*."

Voice no. 7: "*I felt very bad and good at the same time... bad because I could not do the presentation because I didn't have any devices in my home.*"

Voice no. 8: "*Moreover, the charger of our sir's laptop blasted at the last moment. I got thrilled*."

Chapter Summary

An action research study focused on increasing the understanding of mensuration concepts (cones and square-based pyramids) among Grade X students in Kathmandu Valley. This innovative, student-centered pedagogical research was done for fifteen days. It aimed to identify the effectiveness of hands-on (concrete), digital (Pictorial) and collaborative (abstract) learning methods as compared to traditional lecture approaches. Under this chapter, I discussed on the multiple themes obtained from the data collection. I recorded all the data and information as much as possible in the form of text, videos and photos which I used to analyze the major themes and thoughts. With this supportive data, all the themes were explained on different headings. The connected literatures and theories were also described so far.

In the next chapter, I discussed about the finding, results and conclusion of the research by reviewing on the research questions, based on literature and described about the future plan and implications of the findings in short.

CHAPTER V
REFLECTING ON TEACHING MENSURATION THROUGH CPA APPROACH AND FUTURE DIRECTIONS

In this chapter, I generally reflected on the process of my action research with the connection of my past journey as experiences. While conducting the research I personally felt the challenge in identifying the right pedagogical challenge and implementing it with the suitable ICT integration. It also contains the details of introducing the research question, learning theoretical interpretation on the approach and collecting different data as the proof of the research. Moreover, it discusses about the key findings of the day wise collected data which includes observational notes, student's reflections and journal entries. Finally, it includes the conclusions about the effectiveness of the implemented approach, identified limitations and potential future directions.

Retrospection as a Researcher

My research journey was started due to the recognition of my feeling in the number of reducing interest in the mathematics field year by year. Actually, I am the teacher of secondary level for 20 years. During that time, I strongly in touch with my students. I observed them every time in the school. I still remember that the students were little bit sincerer to the teachers in my early period of teaching. Most of us, as teachers, were very much satisfied with our teaching pedagogy. In those days, I used to teach my students using lecture method rather than some other pedagogy. I was influenced by the method that my teacher used while teaching me in the school and I followed a similar approach. It was totally teacher-centered. I also felt proud to myself that I knew everything about mathematics and tried to deliver my all-procedural logarithmic knowledge to them through lecture one-way pedagogical approach. Later, I realized that the method I was applying in my classes was more guided by technical interest Habermas (1972) of knowledge construction. Previously, I was applying just a lecture method and making algorithmic steps of mathematics. This made the level of student's disengagement in learning and low performance in evaluation system. Some of the questions bothered me constantly time to time in my mind.

Why students were so bored in learning mathematics?

Why students were not taking interest to learn mathematics?

How can I engage them in learning? etc.

This led to demand transformative learning method over the traditional lecture method along with new vision and mission in education system. Then, I realized the need of pedagogical change in my teaching. I remembered my learning contents about various teaching and learning methods for better understanding. I went on learning different literature reviews and journals of different methodologies of teaching. There, I found a lot but I was attracted by one of the innovative pedagogies of learning which is CPA (Concrete, Pictorial and Abstract) approach. It is also known as CRA (Concrete-Representational-Abstract) approach of teaching. Actually, it is a three-step instructional strategy for teaching mathematics, originally developed by Jerome Bruner in 1966. It scaffolds learning by moving from hands-on experiences to abstract reasoning, helping students build deep and lasting understanding. The psychologist also believes that the abstract nature of learning (and this is especially true in mathematics) is a "*mystery*" to many students. Therefore, it needs to be scaffolder by the use of effective representations.

Initially, I planned the research by taking a surprise test about mensuration, especially cones and pyramids to observe student's prior knowledge about the specific contents. It was the first time that the students gave the test on the spot without knowing that there was the test. It was really interesting to observe such kind of environment. Student's reflection after checking them showed difficulty in recalling formulas and lack of preparation due to only the abstract nature of learning. This initial assessment underscored the need for a pedagogical shift from purely abstract and textbook-based methods to a more engaging and hands-on approach.

Envisaging My Research Agenda and Formulation of the Research Question

My research agenda focused on addressing the difficulties in understanding abstract 3D geometric concepts with their area and volume calculations of cones and pyramids. This may be because of traditional teaching like teacher-centered and algorithmic which led to low performance in the study. After the reflection on my own teaching practices, I recognized the need for a transformative learning method.

For all the research, every research needs to formulate the research question because it can drive the researcher to the right path. That is why, research question is taken as the important component of research. It was a difficult task for me. In the beginning, I was encountered with the problems that most of the students are not

motivated to learn mathematics. The students were passive in learning process. Most of the students were not able to solve the simple math problems. They were not participating in the classroom interaction too. This passive participation in classroom made me to think about my teaching and learning methods. A possible research question which I initially thought, "*What is the reason behind decreasing interest in mathematics subject in secondary level education?*" popped out in my mind. I searched for better ideas to make students participate in classroom interaction and found many possible pedagogies. Among them, I decided to select and apply CPA approach in my class.

In the beginning, I was in a dilemma in developing the research question. The question should be based on the problems encountered. For this, I went through some published research dissertations available in the University and online and listed some raw research questions on my own. Later, consulting with the supervisor and my faculty members, I modified to 'How does CPA approach of teaching enable engaged and meaningful learning in mathematics?'. After the defense of proposal, the question was modified to "*How does the CPA (Concrete-Pictorial-Abstract) learning approach develop Grade X students' engagement in learning mensuration?*" This question helped to explore how a structured progression through concrete materials, pictorial representations, and abstract symbols could improve student's conceptual understanding and engagement in mathematics.

Research Paradigm and Theoretical Referents

I would like to start writing this part with the saying as the proverb "*You won't know the depth of the river until and unless you jump into it*." (Tyata, 2021). My research is closely related to interpretive paradigm. It is an action research model which is focused on understanding the experiences, reflections and observations of participants within the math lab, digital lab and natural classroom setting. As this paradigm is particularly fit for interpreting qualitative, the chosen pedagogical approach helps to promote the engaged and meaningful learning.

The research had theoretical implications based on the Concrete, Pictorial and Abstract (CPA) model of Bruner (1966) who suggests that the learning process should be scaffolder so that learners can achieve profound and long-lasting knowledge in mathematics. The theory of Bruner suggests that the abstractness of mathematics may be an enigma to children and therefore needs good representations. The CPA framework is also a vital method in the Singapore method of CPA approach of

teaching mathematics with the mastery, which tries to develop on the knowledge that a child already had and to extend it to the abstract concept. This style points out that learners are supposed to continually repeat the stages to and fro in order to reinforce concepts and gain understanding. The principles of collaborative and cooperative learning were also implicitly resorted to in the research since students were often involved in group activities and discussions.

Implementation and Key Observations of the CPA Approach

The Concrete Stage ("Doing")

This stage is the first stage of CPA approach which involves students using physical objects which allow them to experience and handle concrete materials. At first, the concrete models of pyramids as well as solid cones and pyramids made of glass and plastic and models of the Pythagorean Theorem were demonstrated. One of the students stated," *It was nice to be visualized practically*." Their feedback was very positive as the replied that the concepts would remain in my mind for a long period of time. They engaged in a collaborative hands-on activity in the math lab by creating models of square-based pyramids and cones using clay and cardboard. They were happy and excited to be in the lab and actively engaged in learning by doing. Moreover, concrete activities involved constructing cones and square-based pyramids from A4 paper and then making their nets. These activities provided a deep understanding of how 3D shapes are formed. However, these concrete sessions showed some problems related to time and material shortages, which led to delays and some frustration among students.

The Pictorial Stage ("Seeing")

This stage is the intermediate stage of CPA approach which act as the minimizing the gap by bridging between concrete experiences and abstract calculations. While using concrete materials, visual demonstrations of dimensions (slant height, vertical height and radius) and their interrelations were provided using skeletal models and hollow glass cones. This helped students visualize the connections. The class started with the introduction of GeoGebra software in the digital lab. I displayed pre-prepared dynamic 3D models of cones and pyramids, allowing rotation to reveal different perspectives and illustrating Pythagoras relations. The animated demonstration of nets between 2D and 3D was very interesting on the student's eye. The students clapped their hands in excitement because they found that

the visualization through GeoGebra made them memorize faster than before. This made them clearer. Then, students were instructed to construct 3D square-based pyramids and cones, as well as their nets, directly within the GeoGebra software in the computer lab. This hands-on pictorial experience of the learning made the better understand about the structure and formation of cones and pyramids. Students enthusiastically responded, "*I love this software very much, I am enjoying it a lot, I am having fun*". One of the key participants replied, "*It was better than marker-board class.*" At the last, some dynamic sample questions related to mensuration were displayed in GeoGebra, with solution steps one by one. This allowed students to visualize problem-solving processes and the application of formulas.

The Abstract Stage ("Symbolic")

In this stage, students use abstract symbols, numbers, and mathematical notation to solve problems, having developed a solid understanding from the concrete and pictorial stages. The class involved solving exercises from textbooks. Students displayed increased confidence with many capable of correctly calculating answers which indicates improved understanding. They were so engaged in solving the problems and found to compete each other to find their answers. It seemed to be good and helpful class for examinations too. After that, a worksheet with 13 questions categorized by knowledge, understanding, application, and higher ability was distributed. They eagerly started the work in their note copy. They even critically identified an error in the worksheet, LSA vs. CSA for a cone, which demonstrate their deep conceptual understanding. Most of the students successfully completed the problems and found them easy to solve the task due to good prior learning.

A surprise post-test, identical to the pre-test, was taken to test their improvement. The results showed significant progress for most students with higher score than before in pre-test. It was the big improvement for a teacher too. One student reflected that the pre-test was relied on rote learning whereas the post-test was relied on understanding.

In my action research process, I have implemented the PAOR (Planning-Action-Observation-Reflection) framework. The PAOR cycle is the foundational framework for action research, which is defined as a systematic, reflective, and cyclical process aimed at improving classroom practice (Kemmis & McTaggart, 1988).

Engagement and Meaning Making

During the action research, the engagement of students was high with the initial curiosity changing into the active participation. The diversity of activities involved in working with both real-life models and computer-based models supported a dynamic learning process. Students were excited, enjoyed and felt more confident about mathematics. The shared learning and the creation of meaning was achieved through the collaborative character of most activities (e.g., group model making and peer discussions among students). The skill to connect the abstract mathematical positions with the real-world objects and use was also a significant factor in the meaning of the learning process as it advanced towards the participation. The diverse nature of the tasks of working with physical models, as well as with digital simulations, promoted an active learning process. Students said that they felt excited, enjoyed and were more confident in mathematics. It was also urgent that the learning process could be meaningful and permanent depending on the possibility to relate abstract mathematical concepts to real-life objects and applications.

The systematic, four-phase action research process that initiated the development of student engagement and conceptual understanding in this study started with a critical retrospection of twenty years of teaching experience. Understanding that the conventional, teacher-centered approach tended to result in boredom and lack of interest among students, the researcher started the planning process by determining that a radical pedagogical change was necessary. The study was planned as a 15-day intervention based on the Concrete-Pictorial-Abstract (CPA) methodology, which would substitute the mystery of abstract formulas with a systematic scaffolding that would help Grade X students to move through tangible to abstract discovery to symbolic mastery.

The action phase entailed the actual execution of this 15 days plan, which intentionally took the class through the three phases of the CPA framework. Students were brought to math and digital laboratories where they built concrete models using clay and cardboard, interacted with dynamic visualizations and 3D rotations in GeoGebra, and ultimately used these theoretical understandings to solve problems in textbooks. As a facilitator, I was able to remain focused on observation during this period, closely monitoring the participation of the participants by using daily field

notes and observation checklists. These observations showed that the initial curiosity soon turned into active engagement; students were enthusiastic, liked the collaborative activities, and their confidence level increased significantly. This high engagement was supported by quantitative data, which reported that 21 of 23 participants were always attentive during explanations.

These outcomes could be analyzed in depth during the reflection phase, with the emphasis on the way students transitioned between the stage of merely applying formulas without applying formula and the stage of applying them with understanding. Logistical challenges, including the time-consuming character of the activities and difficulties with the availability of resources, were also identified in critical reflection and served as a justification to improve future instructional plans.

Finally, the research gave the most important clue that relating abstract mathematical standpoints to real-life objects and applications is the most important in the development of meaningful and lasting learning. The combination of these four stages allowed the research to demonstrate that the CPA framework is a transformative force that can transform students into active and self-directed learners who perceive mathematical discovery as a meaningful and enjoyable process.

The systematic application of Concrete, Pictorial and Abstract (CPA) approach, as it was demonstrated in the action research, is highly effective in raising the interest of students and creating a comprehensive and long-term understanding of the concept of mensuration. Students who had initially experienced difficulties with working with abstract formulas and lack of interest in the conventional approach started to demonstrate excellent outcomes in conceptual knowledge and problem-solving abilities, as well as confidence. The development of tangible working with objects (concrete) to images (pictorial) and eventually to solving problems in a symbolic manner (abstract) helped students to have solid mental associations and internalization of knowledge. The diverse pedagogical tools, which were physical models, lab activities, GeoGebra software and structured worksheets served different learning types and ensured the high motivation rates throughout the 15-day intervention. This study is based on the fact that mathematics must be contextual and involve learners in meaning building.

Implications of the Study

This study carries several significant implications in the field of mathematics education. For teachers, it motivates to adopt the critical value of adopting a multi-

modal, scaffolding teaching approach like CPA to make abstract mathematical concepts accessible and engaging. It encourages teachers to move beyond purely lecture-based methods by integrating hands-on concrete materials, visual aids and modern technology (e.g. GeoGebra) into their daily lessons. It also helps to experience and handle physical (concrete) objects and make a mental connection between the physical object they just handled and the abstract pictures, diagrams or models.

Similarly, for the curriculum developers, the findings suggest that the curriculum frameworks should incorporate various innovative principles like CPA approach to design the teaching materials. It may promote a balanced progression through concrete, pictorial, and abstract representations rather than premature exposure to abstract concepts.

Moreover, for students, the application of the CPA approach provides deeper conceptual understanding among them by improving problem-solving skills and cultivating a positive and engaged attitude towards mathematics. Students become active participants in their learning, leading to the critical thinkers.

My Insight from the Study

The journey of 15 days of action research around implementing the 'Concrete–Pictorial–Abstract (CPA)' approach has been a humongous catalyst for my personal and professional transformation. I had been a secondary teacher for 20 years and always felt that I was a competent "*algorithmic problem solver*", but I had noticed that there was a drop in engagement of my students, and I wanted to find a way to fix that. Entering the world of practitioner-researcher during my M.Ed. at Kathmandu University was quite a challenge, and it was far more than what I imagined.

Sometimes, my ideas didn't always work out in the classroom. It was often difficult for me to do my research in my free time, given the urgent teaching demands. In the concrete stage, I struggled with a lack of resources, such as scissors and glue sticks, in the math lab which was a waste of instructional time and was frustrating to students and me. In addition, the digital lab sessions came with technical challenges that were not anticipated, including problems with the projector, which required me to be ready to go back to my chair after just a minute or two. These problems were exacerbated by my increasing awareness of the digital divide and how many students did not have the devices at home to practice the GeoGebra skills we were learning in class.

In spite of all these challenges, the meaning making process was very rewarding. I felt guilty for focusing on procedures in the past, and now I feel good for the sense of purpose I saw students gain through conceptual understanding. It was a powerful experience for them and I to see disengaged students applauding the dynamic visualizations in GeoGebra and to see them leading the group-building activities.

The bottom line, this study changed my view of what being a teacher entail. I learned how technology needs to be based on continual reflection and a sense of community. I came out of this with the controlled confidence to promote student-centered, scaffolded learning and learning to be "too soft" on students was never suggested by my principal again. No longer am I just a math teacher but also a reflective practitioner and a change agent in making mathematical discovery a journey for every learner to be inclusive, artistic and permanent.

Limitations

Every teaching and learning practice are limited with respect to participants, place, and time. In the similar manner, CPA approach also has certain constraints. It cannot be generalizable directly but other scholars can go through it and practice transforming it in their practical context. It might be more effective among some group of participants and less effective on others. It might be productive in one context but might not work well in other case. This action research has also encountered some limitations.

The first limitation in my analysis is about the time constraints. The hands-on and technology-based lessons often consumed a lot of time than what was originally intended and often consumed much more time than the conventional lessons. As an illustration, a subject normally taught in two credit hours was prolonged into close to five credit hours. This is a challenge to the achievement of a stipulated curriculum within given periods of time particularly in situations such as Nepal.

Another major limitation is about resource availability and budget. The successful implementation of concrete and pictorial stages demanded an adequate supply of materials such as glue sticks, scissors, projectors, etc. Shortages of these materials led to delays and student frustration. Financial resources were also a concern, as the class needs sufficient budget to conduct these types of hands-on activities which may be hard to manage the students and budget in the case of private school like us.

Also, there is a challenge in dealing with technology along with difference in digital literacy of an individual. It also depends on the nature of the students. Some students still preferred traditional methods as they may found certain activities boring and more struggle with technology or engagement.

Moreover, an action research study is conducted in a specific classroom setting which depends on the environment of the surroundings. The findings may be differed in different contexts. So, it may not be directly generalizable to all conditions or contexts.

Future Directions

This research has made a positive impact in my pedagogical perspective. This study gave the direction to find out an effectiveness of different teaching strategies such as project-based learning (PBL) and lab-based learning (LBL) too. As a teacher, I am motivated to continue and refine the application of the CPA approach in teaching other mathematical topics with positive energy and insights gained. Similarly, I came to know that a teacher needs to investigate and develop strategies for better resource management and time allocation to ensure perfect integration of hands-on and ICT based or technology-enhanced lessons within curriculum constraints.

Further, as a researcher, I am motivated to conduct further research into addressing individual learning preferences and potential anxieties within a diverse classroom, perhaps by exploring more individualized technology use or targeted small-group interventions.

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APPENDIXES

Records of Scores of Pre- and Post-Test

On day 1, I took the surprise test of 20 marks in the class to check the prior of student's knowledge of the content, cone and pyramid of mensuration. Of the 24 students, 23 participated in the test. Similarly, on day 13, I took the surprise test of same questions in the class again as on day 1 to compare their updated understanding of the content, cone and pyramid of mensuration. It was also surprising for them. Of the 24 students, again 23 participated in the test. The results of them are recorded below:

Students Code	**Marks Obtained in the Pre-Test**	**Marks Obtained in the Post-Test**
001	13	18
002	19	Abs
003	16	16
004	17	19
005	8	16
006	8	16
007	4	12
008	16	12
009	17	19
010	12	13
011	5	9
012	6	16
013	7	19

014	17	14
015	14	13
016	2	10
017	5	14
018	2	11
019	2	16
020	3	14
021	12	18
022	5	9
023	7	8
024	Abs	11

Day Wise Observation Notes of Action Research

Day 1 (8th December 2025)

In the first class of my action research, I observed minutely to each student during the test time and paper checking time. It went nicely. Since the test was taken surprisingly, they have experienced a new type of test experience in the class. At first, I described briefly about my research plan. At this time, the students felt a separate type of feeling in their faces because they had heard about the action research for the first time. At the time of the test, they did what they knew through their prior knowledge. They did their best in the exam. Some of them gave their opinion at the end. They said that the class may be more interesting in the upcoming days.

Day 2 (9th December 2025)

In the second class of my action research, I observed minutely introduced the topic by relating it to the questions of a pre-test. I entered with some of the concrete materials like skeletal models of triangular-based and square-based pyramids, solid objects of cones and pyramids made up of glass and plastic and one set of models that describes the concepts of Pythagoras theorem (equation). The students were surprised and excited at that time. Then I described the plan for today's class. I orientated on the topic by displaying the materials. I displayed the solid objects and began to describe the faces, bases and vertices of the cone and pyramid. I tried to make students understand the terminologies used in them along with their symbols like slant height (l), vertical height (h), radius (r), length of the base(a), edge of the triangular face (e), etc. The skeleton of the square-based pyramid and the hollow glass cone made it easier to demonstrate the corresponding lengths (l, r, e, a, etc.). I noticed that the students focused on the demonstration with full concentration and found the classroom more interesting. While explaining, our principal sir entered the class and tried to motivate the students by saying "Listen, our math teacher is working so hard for you all. He is doing his extra duty (because I am taking the class in my leisure time for action research). He is working hard in the class. So, pay him back with the good marks as a return gift. Start your engine and move ahead in your learning journey otherwise, your engine will be seized." Then he went out of the class. After that, I explained the relationship between the lengths used in the objects. I specially explained about different Pythagoras relations (In cone: $l^2 = h^2 + r^2$, in the square-based pyramid: $l^2 = h^2 + (a/2)^2$, $e^2 = l^2 + (a/2)^2$, $e^2 = h^2 + (d/2)^2$. After explaining all, I asked for some content related to the topic of that class. They gave the correct

answers. It made me happy. Then we discussed real-world objects that we could find in conical and pyramidal shapes. They gave lots of examples such as ice cream cones, birthday hats, traffic and training cones, pyramid of Egypt, Ruby's cube in pyramid shape, the pagoda-shaped roof of the temple, etc. By the way, we saw both structures (pyramid and cone) in the roof of two neighbor's house behind the school. It was great. The students felt glad to see these 3 D views live in front of their eyes. Some of them gave their opinion at the end. They said that the class may be more interesting in the upcoming days.

Day 3 (10th December 2025)

In the third class of my action research, I observed minutely the collaborative work done by the students (participants). The class is conducted in the math lab. So, I took all my participants in the lab. I had already managed the required materials mainly clay and card board in the lab. Moreover, I managed scissors, glue, scales, etc. as the supportive materials in the lab. They looked so happy and excited to enter the lab. Then I started the class with the instruction to be followed in the activities in the lab. For this, I divided four different groups of 6 each. I gave three packets of clay and equal pieces of card board to each group. I told them to make one model of pyramid and cone from clay and cardboard. I limited the time of group work within 30 minutes. They were so excited and happy to do the work. I saw that they were doing their hands-on activities with a great interest. In a group, I observed that some are engaged in making cones and pyramids from clay and some were busy in making the solids from card board. I saw one student was helping another in cutting the card board and pasting the edges and bases of the solids with the help of glue. It looked great for me too as they were doing their tasks in a collaborative way. It's good to observe their activities. At the mid of their ongoing activities, I asked about their feelings on such type of work. They replied that they enjoyed on doing this. It was the good and real example of learning by doing by themselves. After 30 minutes of their activities, I told each group to put their finalized materials in front of their desks. The result was awesome. Every group has done their excellent job. They were fully engaged in their work as active learners. I hope that they had learned about the models (structures) of square based pyramids and cones with their engagement mode. I felt the hands-on activities done in the lab was so fruitful. The main reflection I analyzed from my observation is that they learned the concepts with the fun with their great

engagement in the learning process. They said that they wanted this type of lab based hands-on activities more in the upcoming days too.

Day 4 (11th December 2025)

In the fourth class of my action research, I discussed with the students (participants) in detail. I entered the class with the mentality of making the class more interactive mode. The voice of the students will be in the priority of today's class. So, with this mode, I started my class. I started with the overview of the previous classes of action research. I recalled all the previous activities of days 1, 2 and 3 within 10 minutes. During this session, I asked some questions to some of the students related to the topics of the previous classes. They have answered well. It gave me a very good smile because they had taken the concepts correctly. After that, we started to do a discussion based on the properties of cones and square-based pyramids. In this session, we interacted with bases, faces, the curved surface of a cone, the tip of the pyramid, etc. Most of the students are very eager to tell the answers quickly. Moreover, they tried to explain the contents in detail as fast as possible. It feels good for me. However, I found some of the students were not taking part in such type of interaction and discussion time whereas some were expressing their thoughts in a very small voice. It may be due to the introverted nature of the students or may be due to math anxiety. I interact with those students too and motivate them to speak and be interactive in the discussion session. I told them that we should have to talk to the teachers, parents as well as society. We should be socialized. We should have to face the mass all the time in the like journey. For that, we need to practice from right now and try to make them to be active in the interactive session. They took an active participation in the class. It feels like the democratic nature of the class. I liked the today's class very much.

Day 5 (12th December 2025)

In the fifth class of my action research, I made the students (participants) to engage in the hands-on activities. I entered the class with the materials that are used in the activity. The materials are 50 sheets of A4 papers (2 for each), 4 set of glue sticks, 4 sets of scissors, 4 sets of scales and one big carton of card board. I started my class with the instruction that to be followed in the process of activity. I said that each student should have to do the work and completed within the time bounds (30 minutes). The activities are proceeded along with my direction. Then I began to visualize the demo in front of the lab and the students followed my instructions. At

first, I started with the cone. For this, I took one sheet of paper and wrap it in the shape of cone with apex (vertex) at the tip. I attached it with the help of cone. Most of the students could able to follow me but some students were confused to wrap the paper. For them, I along with perfect students assisted very well. There was little crowded in the lab due to shortage of glue sticks. After that I showed the students about cutting the base to make a perfect base with the help of scissors and attaching the base in another piece of paper to form a cone at the last. Students followed the instruction but again there was a problem of scissors and glue sticks due to less in quantity. It took more time because the students had to wait for their turn. It took almost 15 minutes to complete. After that, we proceed to the next part, a construction of pyramid. All the students looked curiously to me for the process of making the pyramid through the sheet of paper. I cut the sheet in the square form and again cut the square sheet in the four equal identical squares. The students did as I do. Then I fold each small squares in identical four isosceles triangles and attached them with the help of glue. The students started to follow me but at the time of attachment again there was a problem. It took almost 15 minutes to complete. Again, it was a time to attach the base in a piece of sheet. They attached the base with the help of glue available with them. I concluded the class with the saying that cut the bases of both after half an hour because the glue will work if it is dry. Also, I left the student's reflection and feedback sheets to them to fill in their appropriate time. From this class, I found that we need an adequate number of materials and lots of time to complete the required tasks planned in the teaching learning process. It's difficult to handle the student's nonsense activities in the lab. It's may be due to the lack of moral education in the today's world. Likewise, the class needs sufficient budget to conduct these types of hands-on activities. So, it's hard to manage the students and budget in the case of private school.

Day 6 (13th December 2025)

In the sixth class of my action research, I made the students (participants) again to engage in the hands-on activities. I entered the class with the materials that are used in the activity. The materials are 50 sheets of A4 papers (2 for each), 1 glue stick and compass, 4 sets of scissors, 4 sets of scales, two punching machines and some pieces of rope which are used in identity cards. I started my class with the instruction that to be followed in the process of activity. I said that each student should have to do the work and completed within the time bounds (30 minutes). The

activities are proceeded along with my direction. Then I began to visualize the demo in front of the lab and the students followed my instructions. At first, I started with the net of cone. For this, I took one sheet of paper and instructed the procedure of making the way with the help of compass and scale. The participants followed the same what I did. After that, I cut the sheet along with the mark in the sheet with the help of scissors. It took almost 15 minutes to complete. After that, we proceed to the next part, a construction of net of pyramid. All the students looked curiously to me for the process of making the pyramid through the sheet of paper. I drew square at first and then four isosceles triangles around the square with specific measurements in the sheet with the help of scale and compass. The students did as I do. Then I cut the required net of square-based pyramid by scale as it is bounded by straight lines. The students followed the same after me It took almost 15 minutes to complete. Again, it was time to punch the hole in the required regions and pass the rope through holes in the net. Moreover, the base was to be attached in a piece of sheet so that the solid structures would be formed after dragging the ropes on each. There was no time to complete the remaining activities in the class. So, I told the participants to write their reflections and feedback in the provided sheets to them in the last 10 minutes. Within this time, I completed the activities from my side and showed the demo to them as a final result. They looked very happy when I explained them through them by pulling the rope. I told them to complete the work at your home and put them in the lab in the next day. From this class too, I found that we need an adequate number of materials and lots of time to complete the required tasks planned in the teaching learning process like this. I felt easier than before to handle the student's activities in the lab because I motivated them to be intelligent in the lab while doing the activity and we should be good learners. Likewise, the class needs sufficient budget to conduct these types of hands-on activities. So, it's not easy to manage the students and budget in the case of private school.

Day 7 (15th December 2025)

In the seventh class of my action research, I took the students to the digital lab. In the digital lab, I explained about what to do and what not to do in the lab. Then, I displayed my presentation slides on the screen through a projector. They were so happy to watch the PowerPoint slides on the screen. In my opinion, they were tired of focusing on the whiteboard only for a long period. They felt different today. So, their faces were smiling. I started to present my presentation. It was all about GeoGebra. I

generally focused on its introduction, history and applications of this software. Most of the students had not heard about the mathematical software named GeoGebra. I presented my slides for about 10 minutes. After that, I displayed some readymade files that I had already prepared at my home. When I displayed the solid objects of cone and square-based pyramids and moved or rotated in the 3D view dynamically, they were very excited to see the screen. They were so glad to see those files as they welcomed the files by clapping their hands. In this session, I displayed about the concepts of Pythagoras relation $h^2 = p^2 + b^2$ in two different models. Then the solid objects with the different Pythagoras relations among the lengths. I displayed the picture by rotating too so that the students could easily identify the symbols of the lengths. They looked good when I displayed the contents. Lastly, I displayed nets of the cone and square-based pyramid with motion. The picture became fiat for the net structures and wrapped the nets for solid structures. It seems that they were enjoying a lot to observe these images on the screen. It took about 20 minutes to display and describe the dynamic images to the participants. Th the last 10 minutes, the students wrote the reflections in the sheet and at that very time I took a short and sweet review of one week class for about 6 minutes from one of the participants. In this way, I ended the class.

Day 8 (16th December 2025)

In the eighth class of my action research, I took the students to the digital lab. In the digital lab, I connected the HDMI cable in the projector but it did not work. The screen of the laptop is not screening in the projector's screen. It feels so bad to me. After knowing this, the students felt bad too. But I told students not to worry. I said "*Don't worry my dear students. We have another extra projector in our school. So, let's go back to the class and connect that extra projector in the class."* After knowing this, they became happy. Then, I connected the projector in the classroom and focused the screen on the whiteboard. It looked great. Now, I opened the GeoGebra interface. Being this software is the first time for most of the students, I explained the interface and some of the major tools to the students by showing them practically. It took almost 10 minutes to explain. After that, I entered to the 3D graphic view and started to construct a square-based pyramid. The environment of the classroom was nice in this time as every student was looking with so enjoyingly and silently. I explained all the steps one by one to the students with reasons. They loved the software very much because I asked some questions related to GeoGebra and most

of them answered "*I love this software very much, I am enjoying it a lot, I am having fun in constructing the pyramid, etc*." After that I started to construct a conical object in the 3D view. The process was similar to pyramid. So, I asked some steps to students before constructing. Most of the students can answer the steps clearly. This looks so good to me as they understand the steps of constructing the objects very well. After constructing the solid objects in the 3D graphic view, I facilitate them to insert text in the GeoGebra. They were very excited to learn these things in the class. Later on, I helped them through the way of constructing nets of both square-based pyramids and cones in the GeoGebra. They loved to do these activities. It took almost 20 minutes to make students clear in the construction process. I motivated them to use that software at their homes also so that they can explore more in the field of GeoGebra. I also instructed them that they should be ready to give the presentation in the lab about constructing these materials in the group. In the last 10 minutes, the students wrote the reflections in the sheet. In this way, I ended the class.

Day 9 (17th December 2025)

In the ninth class of my action research, I conducted my class in the classroom. I plugged the projector in my laptop and directed the screen to the whiteboard. It looked good. Now, I opened the GeoGebra interface. The main aim of today's class is to show some of the sample questions in dynamic files related to cones and square-based pyramids in the GeoGebra software and let them show the solutions step by step by engaging mode. Although it's not my part of action research to make dynamic questions in the GeoGebra, most of the students took an interest in ways to make such kinds of files in the classroom. With due respect to their interest, I demonstrate some of the basic rules and processes of developing or creating dynamic questions in the software. For this, I used the saved files that were constructed a day before. It took around 20 minutes to explain this. I found some of the students so curious to grab such type of knowledge (ICT knowledge). I loved it so much. Then, I started to share my readymade dynamic files related to calculations in cones and pyramids on the screen. These were the files which I made during the lockdown period in the Corona time. At first, I hide all the solution parts and let them understand the questions. They thought and portrayed their understanding one by one. It was great to listen to their understanding as well as the process and formula to be used to find the solutions. After that, I displayed the solution steps one by one on the screen. They seem to enjoy a lot in learning. We discussed about many things in the

teaching and learning process. However, I found two students still sitting passively and not taking part in the discussion. I asked them about this. They replied that they were clear about the contents. There is no need for further discussion in the class. They knew all as I asked them individually some questions. It took almost 15 minutes to complete this session. For the last, 10 minutes, I gave sheets of paper to them to write their reflection and feedback on today's class. In this way, I ended the class.

Day 10 (18th December 2025)

In the tenth class of my action research, I conducted my class in the classroom. I connected the projector in my laptop and focused the screen on the whiteboard. It looked good. Now, I opened the GeoGebra interface. The main aim of today's class is to show some of the sample questions in dynamic files related to cones and square-based pyramids in the GeoGebra software and let them to do the solutions in their copy. I displayed the new question in just one click in the readymade GeoGebra file, and most of the students were surprised in the generating new questions with changes in values. For my easiness, I chose some of the relatable old dynamic files of GeoGebra made at the time of lockdown. I found some of the students were so engaged in solving the problem quickly. They were competing with each other to find the answers. I loved their engaged activities so much. This may be due to the enhancement of their understanding of this topic. I think so. While doing the solution by the students, I hid the solution steps on the screen. Then, I started to show all the steps one by one with a click on the next button. They checked their answers on the screen and assessed their solutions by themselves. This is a type of self-assessment. They seem to enjoy learning a lot. While displaying the last question with solutions on the screen, I request on of my core participants (Nayan Raj Karki) to explain the whole process. He tried his best but I felt he was a little nervous while explaining. For the last, 10 minutes, I gave sheets of paper to them to write their reflection and feedback on today's class. In this way, I ended the class.

Day 11 (19th December 2025)

In the eleventh class of my action research dated 19th December 2025, I conducted my class in the classroom. It was a pretty traditional type of class. I told my students (participants) to take out the book (either textbook or set book). They opened the exercises related to cones and square-based pyramids. Then they started to do some questions. While doing the questions I told my students to share their understanding with their bench partner. I saw that they were in hurry to solve the

problems in their copy. At the time of engagement, two students were kidding with each other. That was the time when I came out of the class to print worksheets for next class. Our principal sir saw those activities from the door. Sir scolded them and made them to stand up from the bench. All the students were so scared of the principal sir in the school. At that very time, I met the sir outside the classroom. He said, "*Don't let them to sit in the whole class. Whey will write their tasks by standing.*" Sir has one objection to me as well. He often told me that I am a good teacher as always but very soft towards the students. Moreover, he always told that despite of delivering good conceptual understanding to the students, students are not so serious in my class. He always said "*Make the students not to move like the statue and make them to listen your voice in the whole class*." Is it good? Are this teaching learning methodology works? Let's think about this later. After that, I observed on the student's work for some minutes. They were busy in doing their work in their copy. It looked nice to see their work. I observer clearly that they have built their confidence in solving the questions in the copy. I found most of the students were capable of calculating the answers of such questions. I felt glad to see this. For the last, 10 minutes, I gave sheets of paper to them to write their reflection and feedback on today's class. In this way, I ended the class.

Day 12 (20th December 2025)

In the twelfth class of my action research, I conducted my class in the classroom. It was also a pretty traditional type of class. I told my students (participants) to take out the exercise copy. They opened the copies. Then, I gave the worksheets to each student containing 13 questions related to cones and square-based pyramids. The worksheet was designed according to the level. The first three questions were knowledge type, then four questions as understanding type, then four as application type and the last two questions were higher ability type. After that, students started to do those questions. While doing the questions I told my students to share their understanding with their bench partner. I saw that they were in so hurry to solve the problems in their copies. I observed on the student's work for some minutes. They were busy in doing their work in their copy. It looked nice to see their work. I observe clearly that they have built their confidence in solving the questions in the copy. I found most of the students were capable of calculating the answers of such questions. I felt glad to see this. In worksheet, I have mentioned lateral surface area (LSA) instead of curved surface area (CSA) in the question of the cone. Some of the

students went on arguing with me that I had made the mistake on that logic. I appreciated them for putting their correct views regarding their understanding. Moreover, students were confused about one question (Q. No. 12). I cleared their confusion by explaining the question and giving hints on the board. Most of them were able to finish the work on time. For the last, 10 minutes, I gave sheets of paper to them to write their reflection and feedback on today's class. In this way, I ended the class.

Day 13 (22th December 2025)

In the thirteenth class of my action research, I took the post-test in the classroom. It was surprising to them again. I did not let them to know about the test. The main agenda of this test is to analyze the effectiveness of the CPA approach in school students in mathematics qualitatively. First, I distributed the answer sheets to write their names. Some of the students looked nervous because of the test. Then I handed out questions. After receiving the question papers, they looked happy. I saw the smile on their face. It's due to the set of questions they had seen in the exam time. I gave the same questions as the pre-test. The main purpose of this test is to analyze the improvement pattern in the student's cognitive domain. After that, they started to do the solutions in a happy mode. The environment of giving exams by the students was very good to observe. They did it at their own pace. Some of them completed within 25 minutes and some took 35 minutes too. They took the exam successfully and seriously. Lastly, I concluded the class by requesting all to fill out the reflections and feedback sheets. In this way, I ended my class.

Day 14 (23th December 2025)

In the fourteenth class of my action research, I intended to conduct my class in the computer lab because it was presentation time for the students. I brought my laptop to school because only one student had sent me his PowerPoint slides in my email the day before. It was nice and I suggested some positive feedback to him. He tried to address all the comments and emailed me early in the morning. I tried to connect my laptop to the projector. But the projector did not work again. I took another portable projector in the classroom and connected it to my laptop. Now, it worked. I focused the projector on the whiteboard. It looked nice. Then I put the presentation slides on the screen. That was the presentation prepared by one of the students named Aarogya Khanal. By the way, I also had a teaching microphone with me. I gave him the device to him. He seemed to be very happy to use it. After that, he

started the presentation. At first, while starting, the nervousness was seen clearly in his face but he built up his confidence thoroughly. He explained everything that we studied in our previous classes. The presentation was good. It took almost 15 minutes to complete the presentation. We spent about 5 minutes to give some constructive feedback and thank you comments to the presenter. For the last, 10 minutes, I gave sheets of paper to them to write their reflection and feedback on today's class. In this way, I ended the class.

Day 15 (24th December 2025)

In the fifteenth class of my action research, I went through the in-depth interview with the core six students about their overall understanding and takeaway. I have recorded all the videos in my mobile. It was great. They gave the mixed comments. But most of them were positive. It took almost 30 minutes to complete the interview. Then, we spent about 5 minutes to tick some objective questionnaire with yes/no options in a sheet. There were altogether 21 questions in the sheet. For the last, 5 minutes, in the same sheet there was a section titled as "Your last words in closing session" in the given individual sheets to them to write something about whole session. At last, I closed the session with my closing remarks and a thank you note. In this way, I ended the last class.

Response of Observation Checklist

Observation Criteria	Responses by number of students	
	Yes	No
Were you attentive during explanations?	21	2
Did you actively participate in discussion and question and answer sessions?	13	10
Were students asking relevant questions or sharing observations?	11	12
Did you collaborate effectively during group or paired activities?	20	3
Were you able to construct 3D objects independently?	16	7
Did you actively engage in lab activities like manipulating solid objects and exploring properties?	16	7
Did you require assistance in making solid objects?	15	8
Did you discover new patterns or properties using solid materials?	18	5
Could you accurately define key terms (e.g., slant height, height, radius, edge)?	21	2
Were you able to explain patterns or relationships observed in solid objects and ICT tools?	13	10
Were you able to reflect and demonstrate understanding of contents?	19	23
Was there noticeable progress in applying appropriate formulas during activities and doing worksheets?	22	1
Did you perform well on pre-test tasks?	13	12

Did you perform well on post-test tasks?	22	1
Were you accurate in completing problem-solving tasks?	19	4
Did you effectively connect theoretical understanding with real world explorations in the lab?	18	5
Were there recurring misconceptions about relationships and formulas of contents?	13	12
Were there technical difficulties with devices or software?	18	5
Did you share unique or creative observations?	12	11
Were tutorials in lab activities adjusted to address challenges?	15	8
Were new approaches used to reinforce challenging concepts?	21	2

Presentation Slides

By Researcher's Side

Slide 1

Presentation on GeoGebra Software

By Niroj Shrestha
Date: 2081\08\29

Slide 2

Introduction Of GeoGebra With History And Application That Can Be Effective For Grade 10 Students

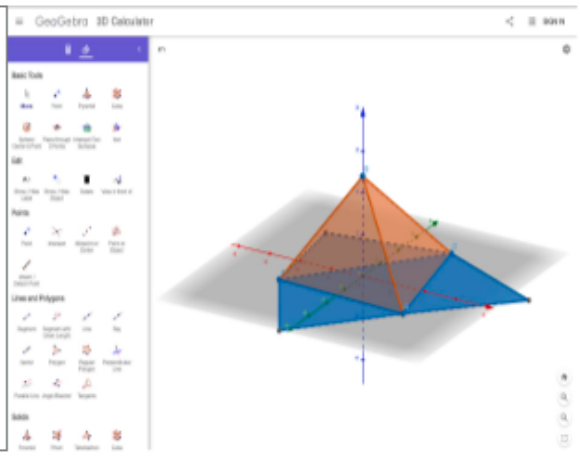
Slide 3

Introduction to GeoGebra

GeoGebra is an interactive mathematics software that combines geometry, algebra, and calculus.

It provides a dynamic platform for students to visualize and explore mathematical concepts.

GeoGebra can be used on various devices, making it accessible for all learners.



Slide 4

History of GeoGebra

GeoGebra was created in 2001 by Markus Hohenwarter, a mathematics educator and researcher.

The software was developed as an open-source project to enhance teaching and learning in mathematics.

Since its launch, GeoGebra has grown significantly, with millions of users worldwide and support for multiple languages.

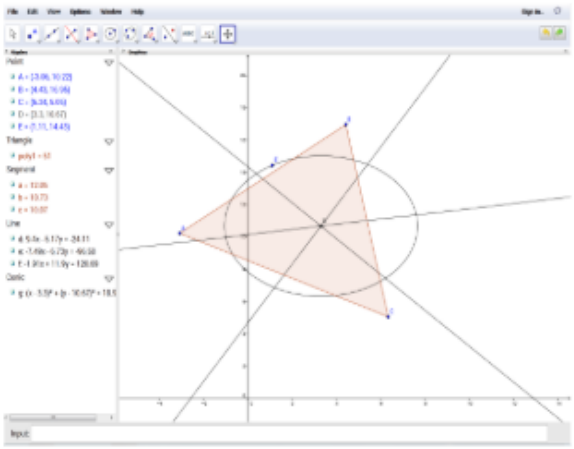
Slide 5

Key Features of GeoGebra

The software includes tools for graphing, geometry, algebra, and 3D visualization.

Users can create dynamic constructions that allow for real-time manipulation of mathematical objects.

GeoGebra also offers a rich library of resources, including tutorials and interactive activities for educators and students.



Slide 6

Applications in the Classroom

GeoGebra can be used to demonstrate geometric concepts such as transformations, symmetry, and congruence.

It allows students to explore algebraic equations and functions through interactive graphs and tables.

Teachers can integrate GeoGebra into lessons to encourage collaborative problem-solving and exploration.

Slide 7

Benefits for Grade 10 Students

Using GeoGebra helps students develop a deeper understanding of mathematical relationships and concepts.

The software fosters engagement and encourages students to take an active role in their learning process.

GeoGebra prepares students for higher-level mathematics by building essential skills in visualization and critical thinking.

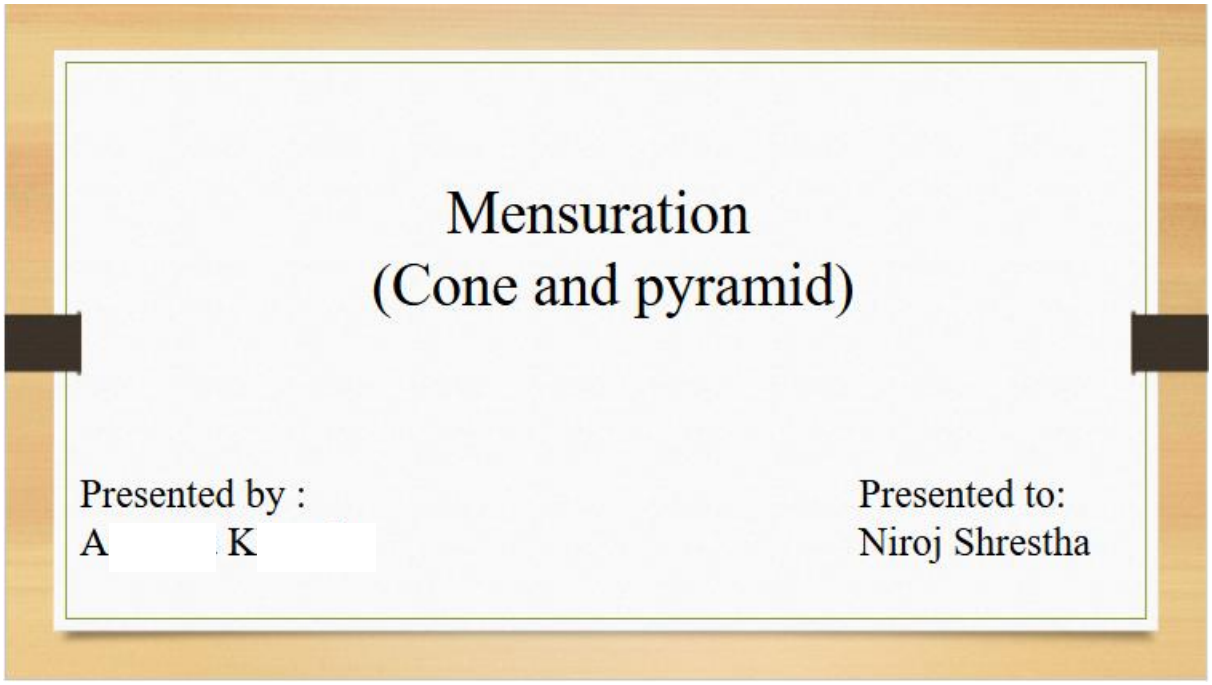
Slide 8

THANK YOU.....

- Niroj Shrestha
- Mathematics Teacher
- Cell no. 9849102098
- shresthaniraj6666@gmail.com

By Student's Side

Slide1



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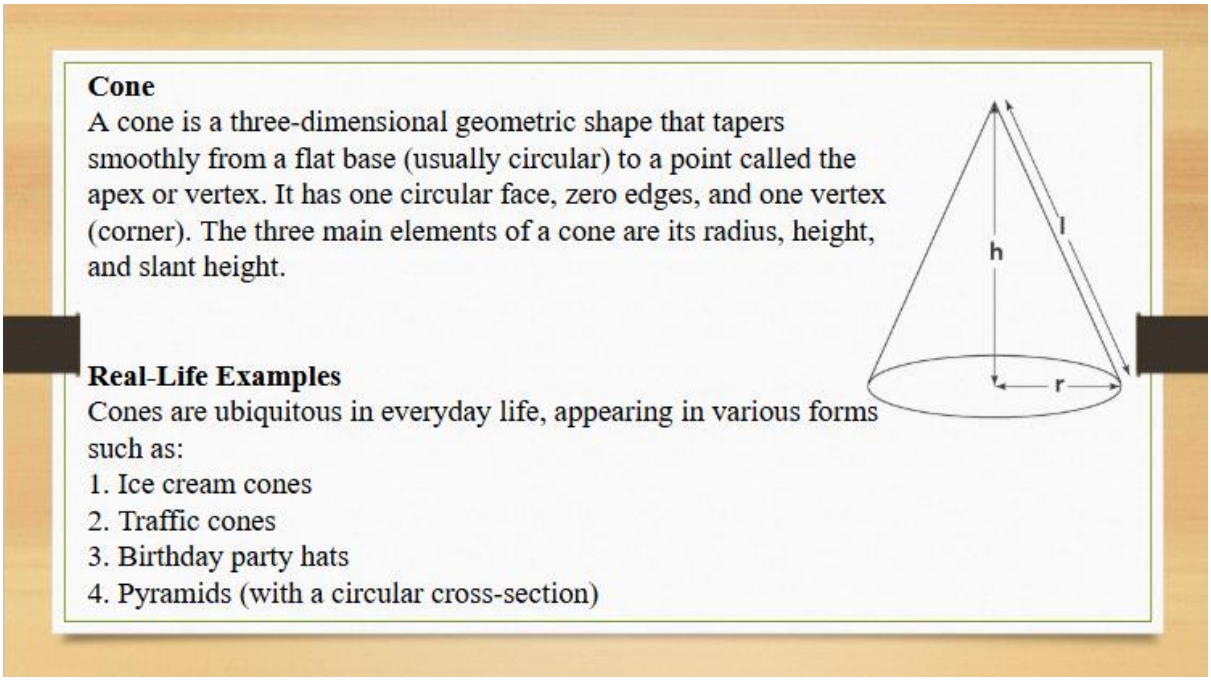


Slide 3

Formulas used in cone

1. Volume of a Cone(V) = $\frac{1}{3}\pi r^2 h$
2. Derived using the Pythagorean Theorem: $l^2 = h^2 + r^2$
3. Total Surface Area(TSA) = $\pi r(l + r)$ or $\pi r^2 + \pi rl$
4. Circumference of base (C)= $2\pi r$
5. Area of base (a^2) = πr^2

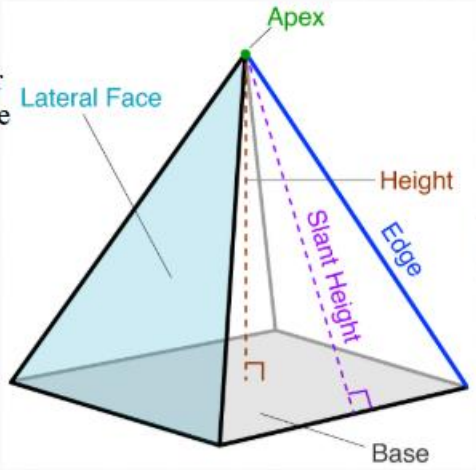
Slide 4

Pyramid

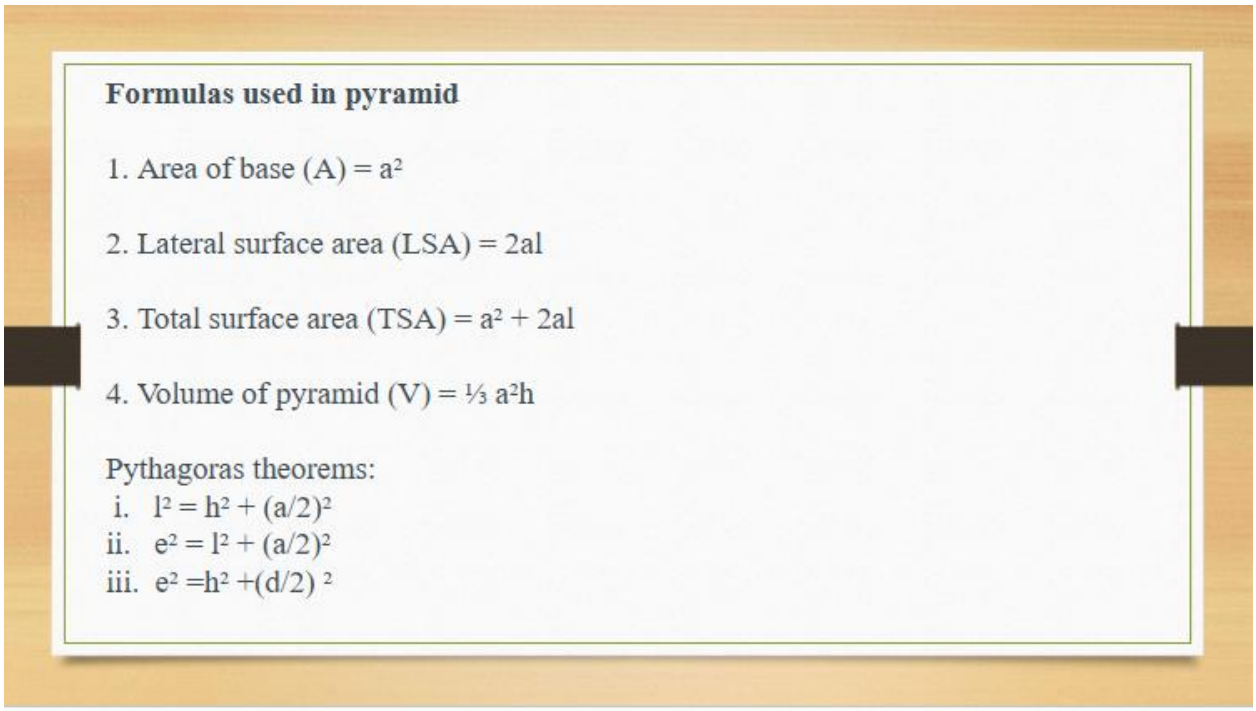
A pyramid is a three-dimensional geometric shape with a flat polygonal base and triangular lateral faces that converge at a single apex. The base can be any polygon, but is most often a square. The lateral faces are triangular, with each side meeting at the apex.

Real life examples of pyramid

1. Tents
2. The Great Pyramid of Giza
3. Buildings and temples
4. Rubik's cubes(pyramid)



Slide 5



Slide 6

Slide 7

Permission Letter to the School

Date: 5th December, 2025

To,

The Principal

Aksharica School

Subject: Request for Permission to Conduct Research in Class 10

Dear Sir,

I am writing this letter for formal permission to conduct a research study titled "CPA Learning Approach for Developing Students' Engagement in Learning Mensuration: An Action Research" in Class 10, as I am the subject teacher of this class. In addition, I am also a student of M.Ed. Mathematics at Kathmandu University. Being a teacher in this school, I am lucky to have the helpful surroundings that help me to have personal growth as well as to do academic research.

The main aim of my research is to improve students' knowledge of mensuration through the CPA (Concrete-Pictorial-Abstract) Approach. During a period of 15 days, I propose to this approach as part of my lessons for teaching mensuration so that the students will learn hands-on, ICT and practice skills towards the attainment of the set learning outcomes. For purposes of data collection, I humbly seek your permission to: (i) Recording of the speech and discussion of the learners in class during the lessons and (ii) Taking photographs and videos of students in learning time.

I can guarantee that all data, such as recordings and photographs with videos, collected will only be used for research purpose. It will stay anonymous and be shared only with my dissertation supervisor and used in my thesis. I will make sure not to further use or let anyone else see the data. Your approval would be a very big help in my trying to make a difference in the students who are in the school and in the teacher's work in our school. I promise I will not do anything that will hurt our school's good work or anyone's values.

Thanks to listening to what I requested. Do let me know whether there are any other conditions or formalities I must satisfy to go ahead.

Sincerely yours,

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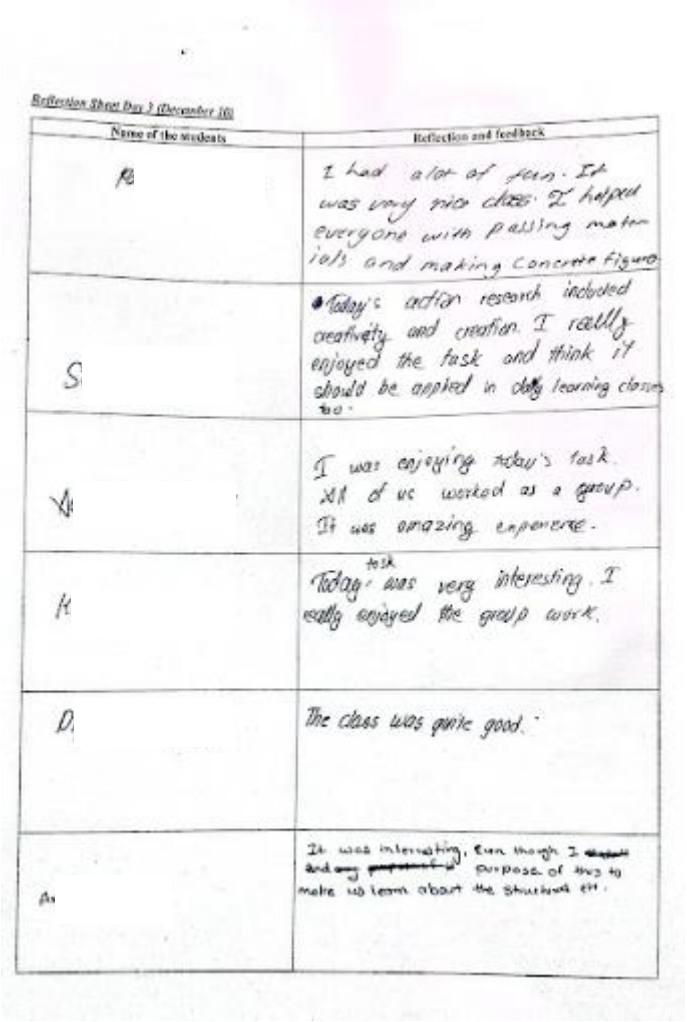
Niroj Shrestha,

Math HOD, Aksharica School

Student's Reflections and Feedbacks

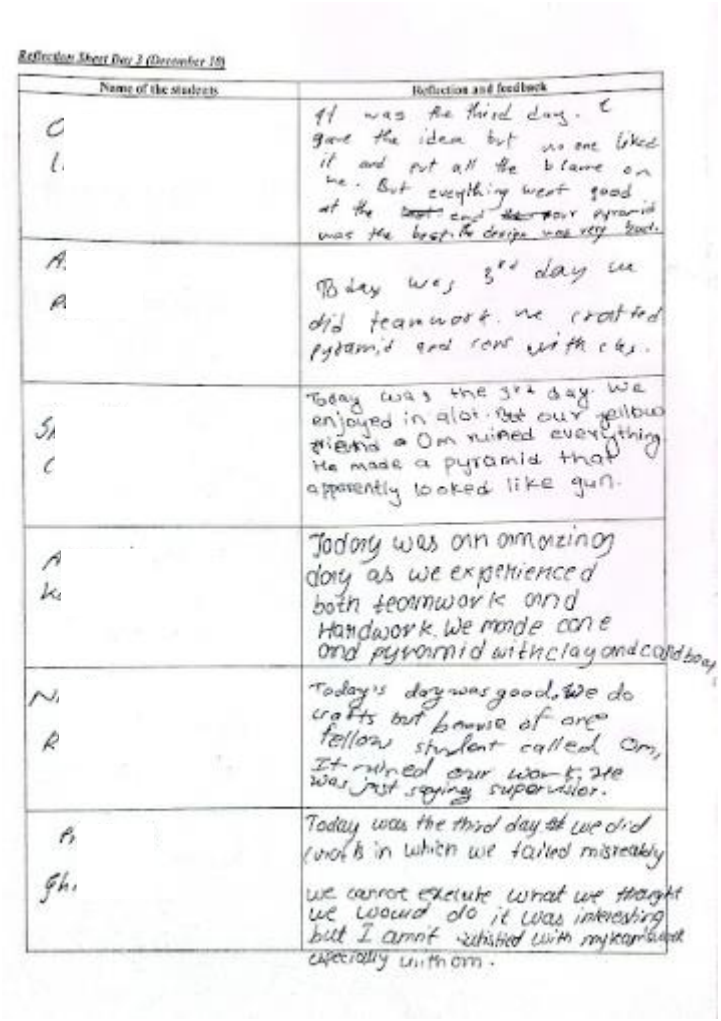


Reflection Sheet Day 3 (December 10)

Name of the students	Reflection and feedback
R	I had a lot of fun. It was very nice class. I helped everyone with passing materials and making concrete figure
S	Today's action research included creativity and creation. I really enjoyed the task and think it should be applied in daily learning classes too.
M	I was enjoying today's task. All of us worked as a group. It was amazing experience.
K	Today's task was very interesting. I really enjoyed the group work.
D	The class was quite good.
A	It was interesting, Even though I [redacted] and my [redacted] purpose of this to make us learn about the structural eff.

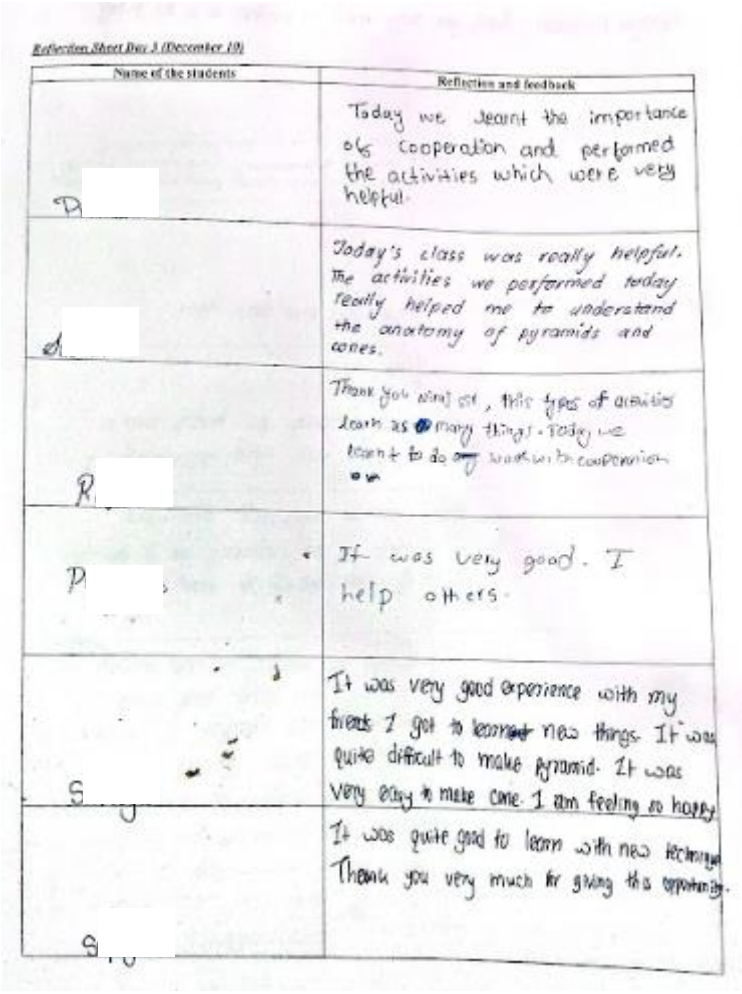
Reflection Sheet Day 3 (December 16)

Name of the students	Reflection and feedback
A	Today class was full of fun. we had lot of fun today - we di made square based pyramid with cardboard and cone with carb board, we made also made cone and pyramid with clay
R	(Day 03) : We had loads of fun today as we got to make shapes of pyramid and cones using clay and cardboard today's class was very fun and interesting.
S	fun and enjoy.
NC	Exciting experience (less time) sir you us less cardboard
S	fun & enjoy. I was an amazing experience . I enjoyed a lot.
A	Day 3 it was fun doing practical. Clay was nice but except the square based pyramid was the worst but we gave all that we can do it was fun.



Reflection Sheet Day 3 (December 19)

Name of the students	Reflection and feedback
C L.	It was the third day. I gave the idea but no one liked it and put all the blame on me. But everything went good at the ~~last~~ end ~~the~~ our pyramid was the best. The design was very good.
A. A	To day was 3rd day we did teamwork. we crafted pyramid and rang with clay.
S. C	Today was the 3rd day. We enjoyed in alot. But our yellow friend Om ruined everything He made a pyramid that apparently looked like gun.
A K.	Today was an amazing day as we experienced both teamwork and Hardwork. We made cone and pyramid with clay and cardboard
N. R	Today's day was good. We do crafts but because of one fellow student called Om, It ruined our work, He was just saying superviller.
A. Gh.	Today was the third day we did work's in which we failed miserably we cannot execute what we thought we would do it was interesting but I amnt satisfied with my work and especially with om.



Reflection Sheet Day 3 (December 18)

Name of the students	Reflection and feedback
D	Today we learnt the importance of cooperation and performed the activities which were very helpful.
d	Today's class was really helpful. The activities we performed today really helped me to understand the anatomy of pyramids and cones.
R	Thank you sir/ma'am, this type of activities learn us many things. Today we learnt to do any work with cooperation.
P	It was very good. I help others.
S	It was very good experience with my friends I got to learn new things. It was quite difficult to make pyramid. It was very easy to make cone. I am feeling so happy
S	It was quite good to learn with new technique Thank you very much for giving the opportunity.

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On this 2nd day of action research, we had learnt about cones and pyramids using physical objects. We revised and learned new things too. This method of learning that includes the proper engazement and of students and teachers by using all of our senses is very good. This makes learning and understanding very efficient aand easy.

Name: S

Reflection:-

Today is the 2nd day of the thesis activity. We learnt many things today. We studied about cone, ~~and~~ triogular based pyramid and square based pyramid. We learnt the Pythagorious therom. ~~to~~ The therom is related with the formulae of the pyramids & cones. By this class, I ~~t~~ notice that it is more easier to learn things visually

Name: S

आज हामीले Cone र Pyramid सिक्यौं। आज चैं हामीले Visualize गरेर पढेको हुनाले दिमागमा याद भयो। अरु teacher हरूले formula पढ्न लगाउनु ~~हुन~~ हुन्थ्यो तर सरले Visualize गरेर पढाउनुभयो। आजचैं हामीले यसरी पढ्दा अलिकति रमाइलो पनि भयो।

D1 [redacted]

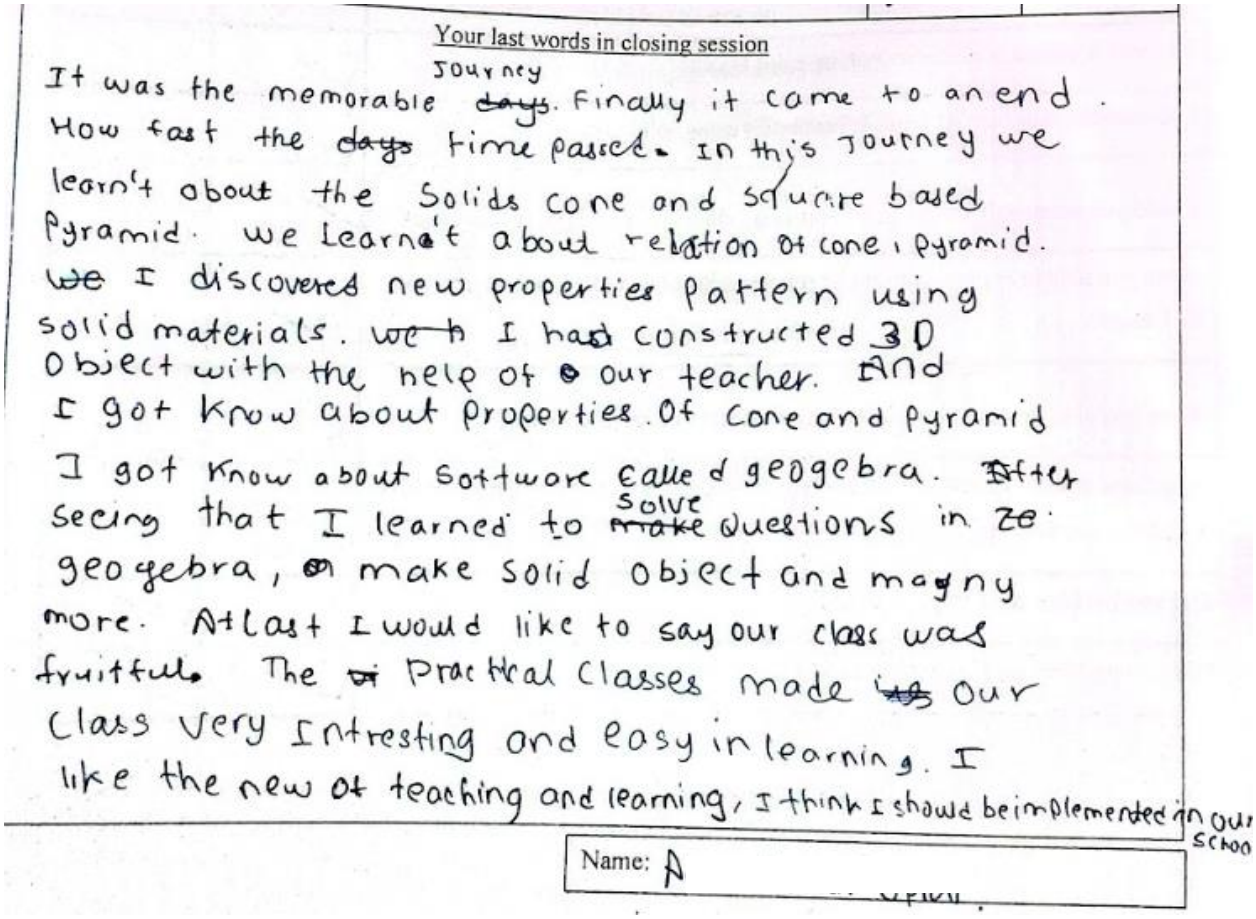
Date
Page

Reflection : Today's class helps me a lot about pyramid and cone. I got many information that I was unware about previously. The demo of concrete materials helps the students to understand things correctly. I also crack out many obstacles that were coming when I used to learn this topic.

Reflection

Name : A [redacted]

Today was a fruitfull day as we learned many new things in a totally new way. It was very fascinating the way sir told us about cone and pyramid. We learned about it the uses of cone and pyramid in real life. All together today's day was full of new learning.



Your last words in closing session

Journey

It was the memorable ~~days~~. Finally it came to an end. How fast the ~~days~~ time passed. In this journey we learn't about the Solids cone and square based pyramid. we Learn't about relation of cone, pyramid. ~~we~~ I discovered new properties pattern using solid materials. ~~we~~ I had constructed 3D Object with the help of our teacher. And I got know about properties. Of cone and pyramid I got know about sottwore called geogebra. ~~After~~ seeing that I learned to ~~make~~ solve Questions in ze geogebra, make solid object and magny more. At last I would like to say our class was fruitful. The ~~of~~ Practical classes made ~~us~~ our class very Intresting and easy in learning. I like the new of teaching and learning, I think I should be implemented in our scho

Name: A

Your last words in closing session

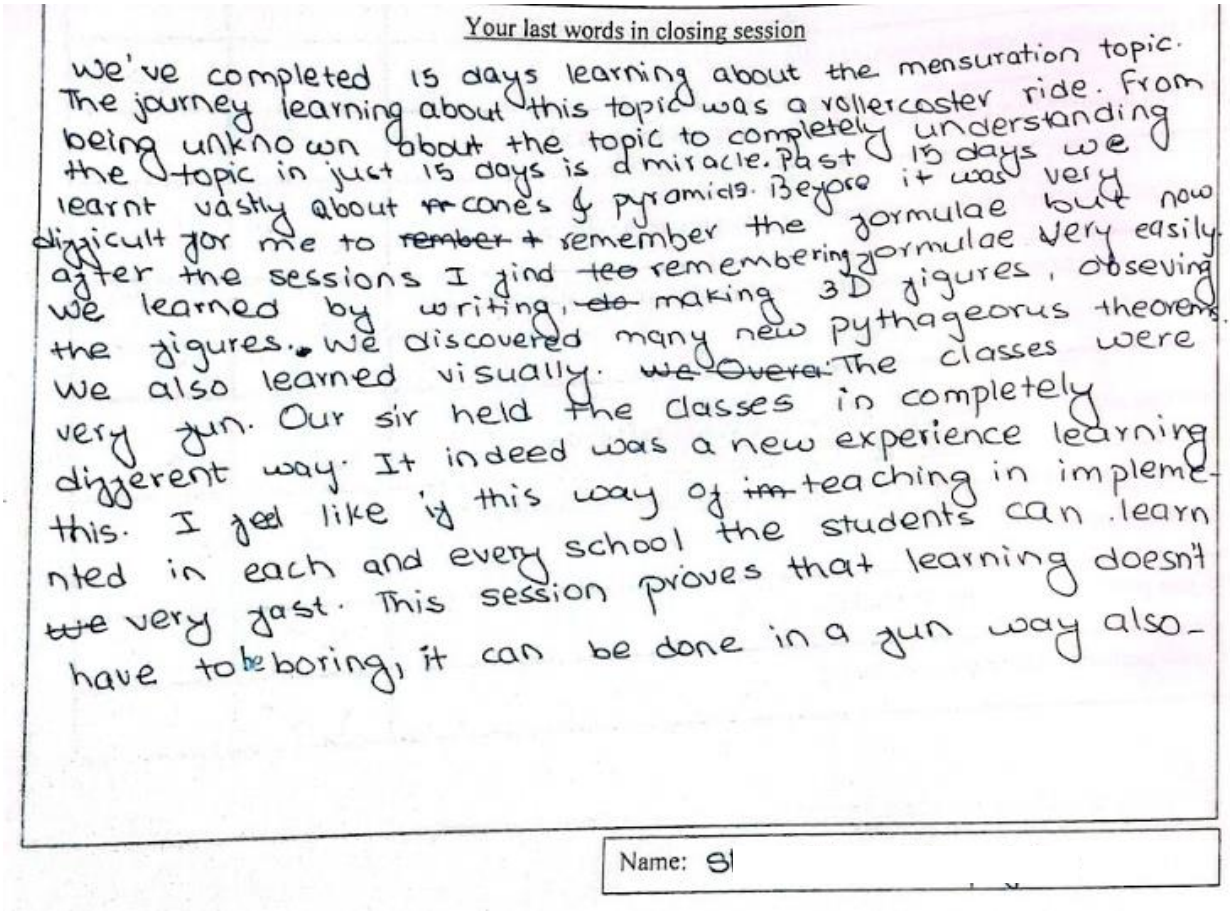
Till today (last day of action research), it was a memorable and fun experience. It helped me recall the chapter and revise for my upcoming exams. I also discovered many techniques and ideas to solve different problems and make solid objects with their nets in a creative manner. Increasing the knowledge and visualized all of the figures for the formulaes, it helped me ~~rember~~ remember through the photographic memory too. I knew about the ICT tools like geogebra which was really worth it. Also. Due to some technical ~~boredom~~ difficulties and teacher's old fashioned teaching. the action reseach

Name: S

Your last words in closing session

Today is the last and closing session of the action research of our favourite sir (Niroj shrestha). We gained good knowledge and experience a good and enjoyable vibes. It was a memorable and fun experience. It helped me recall the chapter and revise for my upcoming exams I also discovered many techniques and ideas to solve different problems and malde solid objects with their nets and creative manner. Increasing the knowledge and visualized all of the figures for the formulae. Also, Due to some technical difficulties and teacher's old fashioned teaching, the action reasearch

Name: S



Your last words in closing session

We've completed 15 days learning about the mensuration topic. The journey learning about this topic was a rollercoaster ride. From being unknown about the topic to completely understanding the topic in just 15 days is a miracle. Past 15 days we learnt vastly about ~~fr~~ cones & pyramids. Before it was very difficult for me to ~~remember~~ remember the formulae but now after the sessions I find ~~tee~~ remembering formulae very easily. We learned by writing, ~~do~~ making 3D figures, observing the figures. We discovered many new pythageorus theorems. We also learned visually. ~~We Overa~~ The classes were very fun. Our sir held the classes in completely diggerent way. It indeed was a new experience learning this. I ~~feel~~ like ~~it~~ this way of ~~tea~~ teaching in implemented in each and every school the students can learn ~~we~~ very fast. This session proves that learning doesn't have to be boring, it can be done in a fun way also.

Name: S