Enhancing Mathematics Teachers' Professional Development for creative teaching in Addis Ababa secondary schools

by

ANWAR SEID AL-AMIN

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DECLARATION

DECLARATION

Name: Anwar Seid Al-amin

Student number: 64087298

Degree: Doctor of Philosophy in Mathematics Education

Thesis title: Enhancing Mathematics Teachers' Professional Development for Creative Teaching in Addis Ababa Secondary Schools

I declare that the above thesis is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references.

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Abstract

The Ethiopian education system is imported from the West, and the traditional method of instruction (pouring information) in the ICT revolution era wastes time and resources. Learners can get more information about mathematics using portable devices such as cell phones, tablets, or personal computers at their homes. The imported school system doubled with the ICT revolution, demanding a change in the role of teachers. Therefore, teachers need training on the new requirements of teaching mathematics. This transcendental phenomenological study aimed to explore the impact of continuous professional development on equipping mathematics teachers with the skill of creative teaching in Addis Ababa secondary schools. The study was framed in the central question: To what extent does the existing continuous professional development program equip secondary school mathematics teachers with the skill of creative teaching? To that end, a qualitative study was done. Six participants were selected using purposive sampling, two from each of the three types of schools: Government, Private, and NGO. Data was collected through one-on-one interviews, lesson observation, and document analysis.

Using Woods' features of creative teaching (Relevance, Control, Ownership, Innovation) and Cremin's dimensions of creative practice (Personal quality, Pedagogy, and Classroom ethos) as a lens to judge teachers' instruction methods, the implication is that teachers fail to practice creative teaching techniques. The study findings revealed that teachers are applying the traditional instruction method, transmitting what is transcribed in the textbook without any adjustment, including its deficiencies. The textbook content lacks logical order among chapters, the tasks are poor in connecting school and out-of-school experiences and are not supportive in fostering teachers' autonomy. The CPD program teachers' experience did not help improve their teaching practices and is not more than for report writing. In this study, the role of teachers in this ICT revolution era has been described; moreover, this study also contributes to the field of mathematics education by paving the way for debate among mathematics education educators on the role of teachers in the ICT and AI (Chat Gpt, Bing Chat) era. The study recommends that the CPD program should equip teachers with creative, challenging, and unusual teaching skills by considering the challenges and opportunities of ICT, real-life mathematics knowledge, the textbook's nature, and teachers' role in this era for meaningful teaching.

Keywords

Mathematical creativity**;** Creative teaching; Continuous professional development; Indigenous mathematics knowledge; Wood's features of creative teaching; Cremin's dimensions of creative practice

DEDICATION

I dedicate this thesis to my family for their love, patience, and supporting me during my studies.

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LIST OF ABBREVIATIONS

CPD: Continuous professional development

MoE: Ministry of Education

EPRDF: Ethiopian People's Revolutionary Democratic Front

ESDP: Education Sector Development Plan

GTP: Growth and Transformation Plan

MSIC: Mathematics and Science Improvement Centre

STEM: Science, Technology, Engineering, and Mathematics

TIMSS: Trends in International Mathematics and Science Study

PISA: Program for International Student Assessment

NEAEA: National Educational Assessment and Examinations Agency

SACMEQ: Southern and Eastern Africa Consortium for Monitoring Educational Quality

CSMASEE: Centre for strengthening mathematics and science education in Ethiopia

Chapter one: Introduction and background of the study

1.0 Introduction

The end goal of any educational system is to cultivate creative and responsible citizens (Kharatova & Ismailov, 2022). Developing these qualities in learners requires creative schools because learners spend most of their active time there. If everything goes as desired, it is where their creative thinking skill is to be cultivated. Teachers are the most influential variable in the school compound on learners' quality. Therefore, teachers need to have that creative competency first. This could be achieved by cultivating creative teachers through well-planned and organised Continuous Professional Development (CPD).

Schooling in the 21st century faces rapid change, requires high standards, and calls for better quality (Inganah, Darmayanti & Rizki, 2023). Hence, teachers should have the skill of creative, challenging, and innovative instruction methods. They also have the need, as never before, to update and improve their teaching skills through professional Development (Kim, Raza, & Seidman, 2019). Therefore, CPD must focus on updating teachers with teaching skills that require 21st-century skills, i.e., creativity. This research intended to investigate the impact of CPD in equipping secondary school mathematics teachers with the skill of creative teaching.

In organizing this chapter, several themes serve as conceptual boundaries for the discussions. The important themes discussed in this chapter are the background of the study, present mathematics teaching in Ethiopia, motivation for the study, statement of the problem, the purpose of the study, its significance, and delimitation of the study.

1.1 Background of the study

Ethiopian indigenous mathematics knowledge is approaching extinction because there is no new indigenous knowledge to replace it (Tessema, 2019). Instead, Western-based mathematics is about to replace our indigenous knowledge through formal education. Unfortunately, our learners are strange to Western mathematics because of differences in socio-cultural background. In contrast, we need them to be good achievers, critical thinkers, collaborative workers, and creative learners who can understand and be mindful of what is happening in the mathematics world around them. In his study, Gebremichael (2019) asks learners if school mathematics is relevant to their lives; they perceive that secondary school mathematics is hardly helpful in their daily activities. In such contradicting realities, our learners cannot achieve the desired competency.

In addition, teaching learners what is in the textbook may have made sense before the ICT revolution because textbooks and references were scarce. There was no internet, television, or much to read other than religious books, but today, in the information age, it is very different. Giving information (traditional method of instruction) to learners wastes time and resources. The teaching materials, assignments in the texts, and their step-by-step solution manuals are readily available on the web. Learners can get more information about mathematics that we teach them using portable ICT devices such as cell phones, tablets, or personal computers and at their homes. Furthermore, most textbooks' content focuses too much on providing them with predetermined skills (Adiredja & Louie, 2020), such as solving quadratic equations, which can be solved using applications. As a result, they may graduate from schools with excellent computational skills but cannot use them in meaningful ways, even though their' creativity must be high on the list of educational priorities (Kozlowski, Chamberlin & Mann, 2019).

Therefore, traditional methods of teaching that involve demonstration and practices using closed problems with predetermined answers do not adequately prepare learners for mathematics and their future careers. Consequently, teachers must be trained and constantly renew themselves with creative teaching skills. This is because teachers are the most influential variables influencing learners' academic achievement and skill more than other school factors. That means the quality of education cannot exceed the quality of its teachers (Schleicher, 2011). An education system is only as good as its teachers (Husbands, 2013). Enhancing teacher excellence at all phases of a teacher's occupation is thus a significant factor in cultivating the quality of education learners acquire.

So what could be done? We cannot remove the teaching materials and replace them with new ones. Instead, narrowing the gap between Western teaching materials and indigenous and out-of-school mathematics knowledge and helping teachers to teach creatively is an optimal solution. It could be introduced to teachers through continuous professional development (CPD). CPD is crucial in empowering the mathematics education community (Bendtsen, Forsman, & Björklund, 2022) on the role of Ethiopian indigenous knowledge, out-of-school experience, and creative teaching methods.

Generally, besides the imported schooling system, the information and communication technology (ICT) revolution brings unprecedented challenges to our school system. These difficulties can be alleviated using effective CPD programs. This CPD should be compatible with the third-millennium information technology revolution, whose tools are creativity, innovation, and discoveries that equip teachers with the skill of creative teaching. Therefore, the central focus of any school system should be cultivating creative and innovative teachers and learners (Zhan, Shen & Lin, 2022). Consequently, the critical duty of teachers is to recognize and cultivate creativity in their learners (Ayllon, **G**ómez & Ballesta-Claver, 2019). The issue of the following topic is what looks like teaching mathematics in Ethiopia.

1.2 A brief history of Mathematics Teaching in Ethiopia

To see the present and recommend what should be in the future, we need to know the changes made to the previous trend of teaching mathematics and their impacts. Historically, Ethiopia practised numerous mathematics education curriculum reforms for over nine decades. However, these reforms were politically motivated and influenced by foreign policies (Tadesse & Kenea, 2022). For example, following the end of the Italian invasion at the beginning of the 1930s, the Ethiopian government formed a political partnership with the British administration. To improve the country's competence in mathematics education, the Ethiopian government chose a British mathematics curriculum divided into two series. The first was called 'Durell and Hudson,' whereas the second was the High Way Mathematics Series.

The "Highway Series," published in England, was translated into Amharic for use in elementary schools. The series focused on computation without understanding, repetition, and memorization. The sequencing of topics was very poor - beginning from comparatively simple examples to complicated examples without any attention to the learner's level of understanding (Dutton, 1968; Weldeana, 2016). These curricula did not understand and support learners' capacity; consequently, they vanished shortly.

According to Weldeana (2016), in 1967, Ethiopia was among ten African nations that adopted "The Entebbe Mathematics Program," a "new math" initiative. This 'new math program" fundamentally developed and introduced by professionals from the United States of America, which was functional until the early 1990s, had no different approach than the previous one that pushes learners to absorb or memorize facts or fragments of information without reasoning. In this program, the paid teacher's job is to efficiently demonstrate or repeat the prescribed information from the textbook or curriculum.

Following the Ethiopian People's revolutionary democratic front (EPRDF) taking power in 1991, a new educational policy document was enacted in 1994. It was the first educational policy in Ethiopia that acknowledged the ethnic diversity of the nation and granted citizens the right to learn in their mother tongue. It is more liberal, encouraging active learning and a learner-centred teaching policy. This policy document (Ethiopia's Education and Training Policy) recognizes learners' role as active meaning-makers in their learning. Teaching should be learner-centred, and the teacher's role should be to facilitate learners' learning, not to be an authoritarian donor of knowledge. The policy documents require learners to think both critically and independently. In addition to applying knowledge in novel situations, classrooms in which a hard-working teacher orchestrates these learner behaviours regularly are exciting. Such a method of teaching is considered as creative teaching.

In enhancing teachers' teaching skills, a series of continuing five-year strategic plans called Education Sector Development Plans (ESDP I - ESDP V) were developed and implemented. Ethiopia implemented the fifth plan, ESDP V, aligned with Growth and Transformation Plan-2 (GTP 2) and covered 2015/16-2019/20. The government formulated policies and strategies to enhance Mathematics and Science Education, like the "Strategies for Improving the Teaching and Learning of Science and Mathematics in Ethiopia" (2010). In addition, Concept Paper for Improving the Teaching and Learning of Science and Mathematics in Ethiopian Schools" (2010) and "Action Plan for Improving the Teaching and Learning of Science and Mathematics in Ethiopia" (2010) were also employed.

The Ethiopian Ministry of Education (MoE) launched the Mathematics and Science Improvement Centre (MSIC) in 2010/11 as a case team under the Teachers' and Education Leaders' Development Directorate. In 2007, Ethiopia joined SMASE-Africa, a regional organization where African nations share practical skills, experiences, and knowledge in teacher education in mathematics and science. Later, SMASE-Africa evolved into more collaboration between Ethiopia and the Japanese government, which led to the development of strengthening mathematics and science education in Ethiopia (CSMASEE). The role of MSIC and CSMASEE was to strengthen and empower science and mathematics learning in Ethiopia to help ensure better achievement. Recently, a program of intervention called STEM (Science, Technology, Engineering, and Mathematics) has been introduced to secondary and preparatory schools to reinforce education in Science, mathematics, and Technology.

One wonders why secondary/preparatory school learners' learning outcomes are low despite all these efforts to enhance quality. The majority of mathematics education remained Western-focused (Weldeana, 2016). Little consideration is given to learners' and teachers' indigenous mathematics knowledge and out-of-school experience, and it stresses memorizing math facts rather than concepts and is more about calculation, not modelling situations. In addition, the works by several mathematicians as curriculum experts, textbooks, and reference book authors reflect and encourage much of Western mathematics. This trend cannot enable teachers and learners to see the relevance of mathematics to their lives. It could result in the misconception of mathematics as a progressive success of mathematicians or Western societies.

1.3 Motivation for the Study

Mathematics is behind all developments made in science and technology. Engineering and technology, states, organizations, companies, medication, and institutions, whether they speak English, French, Arabic, Amharic, Tigrigna, or Zulu, all use mathematics to store and process data (Akinoso, 2023). Gross national product, poverty line, development rate, and academic ranking must be translated into mathematics. An expert who wishes to impact the decisions of institutions and companies must learn mathematics and use it effectively. Mathematics (Algorithm) enables third-millennium learners to use computers to prepare and store their data, communicate with their supervisor, and present their studies online. Computers and artificial intelligence machines use different combinations of binary numbers (0, 1) to communicate with humans. Therefore, mathematics is applied in every aspect of this digital age technology.

Countries recognizing mathematics as a predictor of success in their development participate in international and regional assessments to compare their educational system performance with others (Lerman, 2020). For example, Trends in International Mathematics and Science Study (TIMSS), Program for International Student Assessment (PISA) or the Southern and Eastern Africa Consortium for Monitoring Educational Quality (SACMEQ); Mathematics is the main focus of these assessments to rank present and future technological whereabouts.

Ethiopian MoE (2021) stated that the country has a vision for the education sector development program VI (EDSDP VI), which will be practised from 2020/2021 up to 2024/2025 to make Ethiopia one of the top-performing nations in the region in terms of learner performance in international tests like TIMSS and PISA. The country has not yet participated in global or local assessments (MoE, 2019). It makes it difficult to rank the country's achievement level compared to others. Some international studies show that Ethiopian education quality is in crisis. For example, during the World leaders meeting at UN headquarters, Associated Press (as cited in

Telila, 2010) stated that many organizations, including Education International, Oxfam, Plan International, VSO, and Save the Children, argue that Ethiopia ranks with Somalia regarding the severity of the education crisis.

The government of Ethiopia acknowledged the significance of setting a solid scientific and technological foundation for economic development. In this respect, enhancing Mathematics and Science education is considered an urgent need. To that end, The Ethiopian government developed new policies and methods to improve Mathematics and Science Education, as discussed above. However, secondary school learners' academic achievement is disgusting (MoE, 2023).

For example, as stated in Telila (2010), a study released by Addis Ababa University's Forum for Social Studies in 2009 focused on the crisis in Ethiopia's educational system. According to the findings, only 7.6% of grade 10 Ethiopian learners passed the national secondary school examination in 2007. In the following year, in 2008, it got worse when only 3% of the learners scored passing results nationally. Similarly, in 2008, approximately 60% of learners received a grade of less than 25% on the National Secondary School Leaving Examination.

When it comes to the subject of mathematics, it is even worse. A study published by the education statistics annual abstract of the Ethiopian Ministry of Education (2017) focuses on the results of grade 10 learners by subject. Mathematics had the highest number of learners that did not sit for the exam, with 21,896 (1.85%) learners not taking the exam, followed by history with 9643 out of 1,183,242 learners. It indicated they did not feel safe with mathematics compared to other subjects. The study also revealed that in 2016, the number of learners who scored A grade was 4.75%, which is the least compared to other subjects, followed by Geography at 7.03%.

Another study by Jebena (2013) was on achievement scores concerning performance level. The performance levels were divided into four standards: advanced, proficient, basic, and below basic. Four years later, the National Educational Assessment and Examinations Agency of MoE (2017) also analysed the achievement score regarding performance levels. Of the learners who sat for grade 10 national examinations in 2010 and 2016, more than 50% are below the basic level in mathematics, as shown in Table 1.1. It indicates that we must improve the quality of education, particularly in mathematics.

Table 1. 1 Grade 10 learner performance level in 2010 & 2016

Academic year	Performance level (%)			
	Advanced	proficient	basic	Below basic
2010	6.2	8.7	24.4	60.7
2016	5.7	4.1	38.8	51.4

Due to the education system introduced in 2019/20, the grade 10 national examinations were scraped. Currently, there are no grade 10 national examinations. When we come to the learners' results of the national examination of grade 12 in 2022, it is the worst-ever result scored in Ethiopian history. The examination was conducted in universities to minimize cheating. According to University World News (2023), out of 896,520 learners, only about 29,909 obtained the pass mark (average and above), which is only 3.3% of learners get the pass mark (6.8% of natural science, and 1.3% of social science). Out of 2,959 schools, not even a single learner does get a passing mark in 1,161 schools. The lowest national average result was scored in mathematics, 25 out of 100. In 2023 G.C., 845,188 learners took the national grade 12 exam; in total, 27,267 learners (which is 3.2%) scored 50% and above (NEAEA, 2023). Grade 10 and 12 national examinations contain only multiple-choice questions. Here, learners can get the correct answer by guessing. It indicates the deepness of the crisis. The question is, what are the sources of this crisis?

1.4 Statement of the Problem

Ethiopia's educational system is based on the constructivist teaching and learning theory (MoE, 2023), underpinning the competency-based education concept (Jemberie, 2021). Competency refers to a learner's ability to apply knowledge, skills, attitudes, and values independently, practically, and meaningfully. In such a setting, the role of a mathematics teacher is to teach in creative, unusual, and challenging methods of instruction. Unfortunately, many studies indicate that teachers teach how they are taught in school (Oleson & Hora, 2014). This idea is in line with

Mengistie (2020), who concludes that Ethiopia's teaching and assessment trends focus much on learners' skills of memorizing formulas in contrast to the education policy of constructivist teaching and learning theory. The study does not ignore the importance of memorizing formulas but should be connected to logical, critical, and creative thinking skills. However, learners develop these skills only if their teachers are competent in creative teaching skills (Schleicher, 2011). As a result, learners' secondary school mathematics achievement becomes poor (Tiruneh, Rolleston, Sabatesa, & Hoddinott, 2022), as described above in section 1.3.

There are many contributing factors to learners' poor achievement. For example, lower achievers in university entrance exams are joining the teaching profession as teaching is not a profession of choice (Kassa, 2014) because of the low salary compared to the cost of living. These teachers teach mathematics from a foreign-based curriculum and textbook using a foreign medium of instruction (Gebremichael, 2019). Consequently, significant numbers of teachers conventionally teach mathematics with little or no conception of mathematics as having a socio-cultural foundation (Ayalew & Areaya, 2021). As a result, learners perceive secondary school mathematics as hardly valuable for everyday life and society (Gebremichael, 2019). They consider it the isolated success of civilized Western society (Izmrili, 2011).

Consequently, learners may spend more time searching for solutions on AI (such as Chat Gpt and Bing Chat) than doing by themselves for the assignment provided by their teachers. The lessons and the textbooks influence the perceptions of relevance by presenting mathematics topics with few practical applications in everyday life or Ethiopian society (Gebremichael, 2019). This scenario assigns learners the role of grasping the theory but does not give them a clear concept of where and how to apply it. This trend negatively affects learners' thinking skills and achievement (Weldeana, 2016).

One may think these challenges could be solved through effective in-service training. The CPD program developed at the national level considers creative teaching methods and the socio-cultural perspective of mathematics. However, it gives more responsibility to experienced school teachers (MoE, 2009) who may not acquired the required skills (Mengistie, 2020).

A gap exists in the research. Most of the research concerning the creative teaching of mathematics has not been conducted by mathematicians (Zamir & Leikin, 2011). In addition, the few studies conducted by mathematicians in Ethiopia are not more than 'teachers' perception of creative teaching and learning (Ayele, 2016; Jemberie, 2021). Therefore, the need exists to analyse creative teaching conducted by mathematicians at the secondary school level and within the Ethiopian context.

1.5 Purpose of the study

The main aim of this study is to explore the impact of continuous professional development on equipping mathematics teachers with the skill of creative teaching in Addis Ababa secondary schools.

1.5.1 The specific objectives of the study

In achieving the goal, the main aim of the study was divided into the following specific objectives:

- ✓ Identify the perception of mathematics teachers towards creative teaching of mathematics.
- ✓ To determine the extent to which official textbooks and suggested teaching materials teachers use in teaching mathematics relate to teachers' and learners’ real-life context.
- ✓ To analyse the creative teaching practice of secondary school mathematics teachers.
- ✓ Investigate the role of the existing CPD in equipping mathematics teachers with the skill of creative teaching.

1.6 Research questions

The study addresses the following research questions.

Main question: *To what extent does the existing continuous professional development program equip secondary school mathematics teachers with the skill of creative teaching?*

Sub questions

The main research question is divided into the following questions:

1. What are mathematics teachers' perceptions of creative teaching of mathematics?
2. How do the official textbooks and suggested teaching materials used in teaching mathematics relate to teachers' and learners' real-life contexts?
3. To what extent do mathematics teachers apply creative teaching practices in their classrooms?
4. What is the role of the existing CPD in equipping mathematics teachers with the skill of creative teaching?

1.7. Significance of the Study

This thesis's primary purpose is to explore to what extent the existing continuous professional development equips mathematics teachers with the skill of creative teaching. The study also analyses the creative teaching practice of secondary school mathematics teachers. For the 21st century's unpredicted future of education, pedagogy experts recommend that schools teach 4C skills (Zakiah & Fajriadi, 2020). These include creativity, critical thinking, communication, and collaboration in understanding concepts other than dictating what someone else writes. No educational system could be outstanding without recognizing and incorporating creativity into teaching and learning (Pllana, 2019). Creative teaching and learning practices make content learning more effective and engaging (Sawyer, 2019). It improves student achievement (Fuentes-Cabrera et al., 2020).

So, to impose these qualities and skills on our learners, mathematics teachers should have these skills first; that is why this study is essential. This study may also be helpful for curriculum developers and textbook authors in integrating real-life mathematics knowledge into secondary schools. The study also assesses the extent to which official textbooks and suggested teaching materials teachers use in teaching mathematics relate to learners' real-life context. In addition, since to be creative, we should start from what we have, know, and experience in our socio-cultural activities, this study gives insight into indigenous knowledge of mathematics in Ethiopia for further research.

1.8 Delimitation of the Study

The study is limited to mathematics teachers and was focused on creative teaching strategies. The study describes the process of developing creative teaching skills and analyses the teachers' experiences but does not evaluate its impact in the classroom because of the study's time constraints. The research was not conducted on the expected site, in South Eastern Tigray Secondary Schools, because of the unforeseen war that erupted on November 3, 2020. This site change may have an impact on collecting rich real-life mathematics knowledge of the rural areas.

1.9 Layout of the Study

The thesis is divided into five chapters. The research problem and its context were highlighted in the first chapter, which served as an advanced introduction to the study’s background. Some previous valid studies in teaching mathematics are briefly discussed. This chapter explains why this study is essential and provides context for the research problem. An overview of some of the factors that led to the current state of Ethiopia's mathematics education system is presented. The study’s significance is also explained. The chapter ends by summarizing the thesis's outline and clarifying some key terms.

The review of related literature and an explanation of the study's lens are both included in chapter two. The Theoretical Framework is employed, pinned on Wood's features of creative teaching (ownership, relevance, control and innovation) and Cremin's dimension of creative practice(personal quality, pedagogy and classroom ethos). Following this chapter, the research methodology is discussed in chapter three. The methods used to conduct the study are explained in more detail.

Chapter four presents the analysis and discussion of the gathered data. Chapter four's overview gives emerging themes derived from each research question. The final chapter, chapter five, is about the study's summary. It reports on the study's Recommendations and conclusions, including a portion of the thesis's contribution to new knowledge.

1.10 Definition of key terms

The following words and terms that are repeatedly used are defined to create a shared understanding of the study.

Continuous Professional Development: The Development of professionals to exploit their maximum potential in executing their professional role after completing their initial training.

Creative teaching: a combination of logical and divergent teaching, a teaching strategy designed to aid learners in learning new content in ways that will allow them to apply what they have learned to new issues.

Ownership: The instructor and learners exhibit autonomy by taking responsibility for all areas of the learning process.

Innovation: The teachers and learners create novel and inventive techniques to push the boundaries of what is normal.

Control: The capacity of the instructor to employ inclusive pedagogy.

Relevance: The importance of mathematics content teachers teach and learners learn in their lives.

Personal Characteristics. The qualities and characteristics of innovative teachers.

Pedagogical practices. The innovative teachers strategies and techniques in teaching mathematics.

Classroom Ethos: A classroom's overall mood or spirit, including teachers' settings for the student's physical and social environments.

Secondary school: Ethiopian secondary education is from grade 9 up to grade 12.

Addis Ababa Is the capital city of Ethiopia.

Wereda: The Ethiopian administrative division is governed by a local administration.

Gebeta: is a traditional game in Tigray, Ethiopia.

Chapter 2: Related literature review and theoretical framework

2.0 Introduction

Empowering teachers' skills toward creative teaching through continuous professional development is the core construct of this study. From the background information in the previous chapter, it is clear that one of the priorities of CPD in the third millennium is to equip teachers with creative teaching skills. Accordingly, this chapter reviewed some related literature and research findings to provide background information for the study. An overview of research literature on the primary three constructs: creativity in general, with a particular focus on creativity in teaching mathematics, continuous professional development strategy to equip mathematics teachers with the skill of creative teaching theoretical framework of the study is provided. In the theoretical framework section, Woods's (1990) features of creative teaching and Cremin's (2009) dimensions of creative practice are used together as a lens for this study.

2.1 Creativity

Researchers have made several attempts to define creativity. In contrast, these efforts come with unrelated and sometimes contradicting definitions (Grigorenko, 2019). Creativity as a study problem is wide-ranging, unwieldy, and difficult to grasp (Hernández-Torrano & Ibrayeva, 2020). In confirming this, Franceschelli and Musolesi (2021) recognized more than one hundred current definitions of creativity, which is still growing.

Some scholars define mathematical creativity by reviewing the process genius mathematicians precede in achieving their genius work. For instance, Hadamard (1945) studied the experience of prominent mathematicians. He theorized that Wallas's (1926) four stages were appropriate in labelling mathematicians' work. The four stages are preparation, incubation, illumination, and verification. Others consider the work the end product; what makes it creative? The work or product should be 'new, high quality and appropriate' (Kim, Roh & Cho, 2016, p.39), novel, and useful (Ayas & Sak, 2014). Others consider the interaction between individuals and their environment. According to Rhodes (1961), the word press signifies the influence of the environment on individuals who cannot be creative in isolation; they need external stimuli to spark their imagination. Therefore, creativity in mathematics can be seen in four general categories (4p's): person, process, product, and press (Joklitschke, Rott & Schindler, 2022).

This study's most pertinent definition of creativity encompasses the 3p's (person, process and press), the capacity of teachers to integrate "… valuable ideas or behaviours generated from the interaction between a person's thinking and sociocultural context" (Kim et al., 2016, p. 39). In this study, creativity in teaching mathematics is associated with teachers' mathematical reasoning skills in the problem–solving and problem-posing process (process), their personal quality (person), and classroom management skills (press).

The reasoning sequence in solving and posing problems must be new, relevant, and surprising to the learners. The content need not be mandatory to be the original work of the teacher. The teacher may use a forgotten technique in a way that is sufficiently fluent and flexible enough to avoid fixations (Joklitschke, Rott, & Schindler, 2022). For instance, in teaching quadratic equations, teachers can introduce the concept as stated in Alkhelili (2015), an ancient Babylonian problem found in the cuneiform (the oldest form of writing) text reads:

'What is the number that, when added to its reciprocal, gives a known number? ' This idea can be stated algebraically as letting the unknown number be 'x,' and the known number be 'b' then can be written as like $x + \frac{1}{x} = b$ Rearranging it gives $x^2 - bx + 1 = 0$, which is the concept of a quadratic equation.

The researcher does not mean the door for the unique process and product is closed in this study. Reasonably, it is encouraged, especially in teaching strategies and classroom management systems. However, in terms of content, original work is done by a few mathematicians. Therefore, the concern of this study is for almost every mathematics teacher; it recognizes that each teacher is not expected to come up with original and valuable works in terms of content. If creativity in this study is defined as the skill of reasoning sequence of teachers in solving and posing problems, what is mathematical creativity?

2.1.1 Mathematical Creativity

Hansen (2022) defines creativity in mathematics as the sequence of reasoning by which original and new answers are found for particular problems and the generation of new problems or viewpoints on current ones. Similarly, for Assmus and Fritzlar (2022), the process comes with novel and insightful answers to a given unpredictable task. At its advanced level, mathematical creativity is defined as boundary-pushing. For instance, Liljedahl and Sriraman (2006) explain mathematical creativity as: "*the ability to produce original work that significantly extends the body of knowledge, which could also include significant syntheses and extensions of known ideas." (p.18)*

This study's definition of mathematical creativity is based on teachers' problem-solving and problem-posing skills. In this sense, teachers find creative outlets in solving and posing new problems (Kozlowski, Chamberlin, & Mann, 2019). Uwaezuoke and Charles-ogan (2016) conclude that mathematical creativity at the school level is teachers' skill to examine a problem from different viewpoints, see patterns, differences, and similarities, develop multiple ideas, and pick an appropriate strategy to tackle challenging mathematical tasks. It "includes the ability to see new relationships between techniques and areas of application and to make associations between possibly unrelated ideas" (Haylock, 1987, p. 60).

The reasoning skill of teachers in problem-solving and posing can be evaluated in terms of the measurable indicators of creativity: fluency (flow of associations), flexibility (approaching a problem in various ways), originality (a unique way of thinking, and original products of mental activity), and elaboration (the capability of describing, illuminating, and generalising concepts) (Torrance, 1966). The four indicators are mutually related; however, not all need to happen simultaneously.

This research aims to investigate the degree to which mathematics teachers use creative teaching techniques. Here, teachers are not required to innovate and use their original works but to practice what is known fluently and flexibly by integrating existing knowledge. Hence, boundary-pushing and original work are not the most important issues of the study.

2.1.2 Historical Value of Mathematical Creativity

Throughout history, mathematics has played an essential role in shaping human life. Even the meaning of mathematics changed over time because of the invention of new concepts (Russell, 2022). During the Egyptian and Babylonian civilizations, mathematics was solely arithmetic; hence, it was the study of numbers. Later, Greek mathematicians came up with geometry, and numbers were used to measure lengths; as a result, they found irrational lengths. Here, mathematics was the study of numbers and shapes. Lately, Newton (1665) and Leibniz (1670s) invented calculus. Calculus comes with new techniques to deal with change and motion. Mathematicians make it possible to study the motion of planets, expansion of gases, fluid dynamics, falling bodies on earth, flight, predict the spread of epidemics, economic fluctuations, and even most government decisions need this science. Following the invention of calculus, mathematics became the science of numbers, shape, motion, change, and space.

The radical transformations in science and technology are unthinkable without the creative work of mathematicians. For instance, in the Middle Ages, Persian mathematician al-Khwarizmi came up with the revolutionary discovery of algorithms; without algorithms, there would not be computers, artificial intelligence machines, ICT devices, or Silicon Valley. Learners will not exchange emails with their supervisors. An algorithm is everywhere in third-millennium technologies that transform human life. Mathematician Kim Rossmo (2000) recently developed criminal geographic targeting (CGT), a model used by police departments in several countries. All these are the fruits of mathematical creativity.

Unfortunately, creativity in teaching mathematics has been ignored for a long time. When Haylock (1987) reviewed educational literature published from 1966 to 1985, she confirmed that the concern of creativity in mathematics education research had been neglected. Similarly, Sternberg and Lubart (1999) found that through the 20 years from 1975 to 1994, about 5 % of the studies in mathematics education abstracts were related to creativity. Lately, Lev-Zamir and Leikin (2011) investigated journals from 1999 to 2009 in seven eminent research journals in mathematics education and seven renowned journals in gifted education. They revealed that few articles (papers) in mathematics education were devoted to creativity-related issues, whereas research on creativity within general psychology gave little attention to mathematical creativity.

Thankfully, this topic has recently received increased attention from the mathematics education community. Publications like Lev-Zamir and Leikin (2011), Leikin and Sriraman (2022), and Joklitschke, Rott, and Schindler (2022) support this observation.

2.1.3 Framing Mathematical Creativity for this Study

As discussed above, mathematical creativity is multifaceted, and different academics have varied perspectives (Leikin & Sriraman, 2022). Among the primary challenges when researching the creative teaching of mathematics is the absence of a precise and widely agreed definition of "mathematical creativity" and creativity itself (Schoevers, Kroesbergen & Kattou, 2020). The notion of creativity is wide-ranging. Therefore, it is essential to frame mathematical creativity according to this study. The research focuses on the skill of creative teaching that every average mathematics teacher could master.

The difference between Big C (absolute creativity) and Little C (relative creativity) is essential to this study. Most studies on creativity take either of the two ways (Beghetto & Kaufman, 2022). The first way, Big C, is associated with the outstanding historical creativity of geniuses (e.g., the works of Pythagoras). In contrast, little c (relative creativity) is associated with everyday creativity. Everyday creativity refers to experiences and expressions that practically everyone can access, which is the concern of this research. For instance, a creative instructor is a teacher who tries to connect the subject to learners' lives or teaches mathematics as a science of life and order.

Similarly, this research needs to clarify the difference between general and specific creativity (Huang, Peng, Chen, Tseng & Hsu, 2017; Schoevers, Kroesbergen, & Kattou, 2020). Here, general creativity is to use mathematical techniques to address problems in another field, such as the works of Kim Rossmo discussed above. In contrast, specific creativity refers to teachers' creativity in teaching mathematics during problem-solving and posing new ones in that field, such as solving mathematical tasks that may arise from learners. This study focuses on specific creativity, teaching mathematics creatively for a better understanding of the subject by learners**.**

2.1.4 Creativity in terms of teaching mathematics

Teaching mathematical topics without reasoning does not help learners understand the concept and appreciate the beauty of mathematics; as a result, they find the subject abstract, tedious, and challenging to understand (Dyer, 2020; Langoban & Langoban, 2020). Therefore, enhancing creativity-based mathematical instruction is very important in third-millennium schooling. Definitions from previous research studies show that creative teaching in a mathematics classroom revolves around two discourses. Should teachers focus on learners' desires and teach learners based on their interests, or should they focus on the mathematics curriculum and teach the course efficiently to their learners?

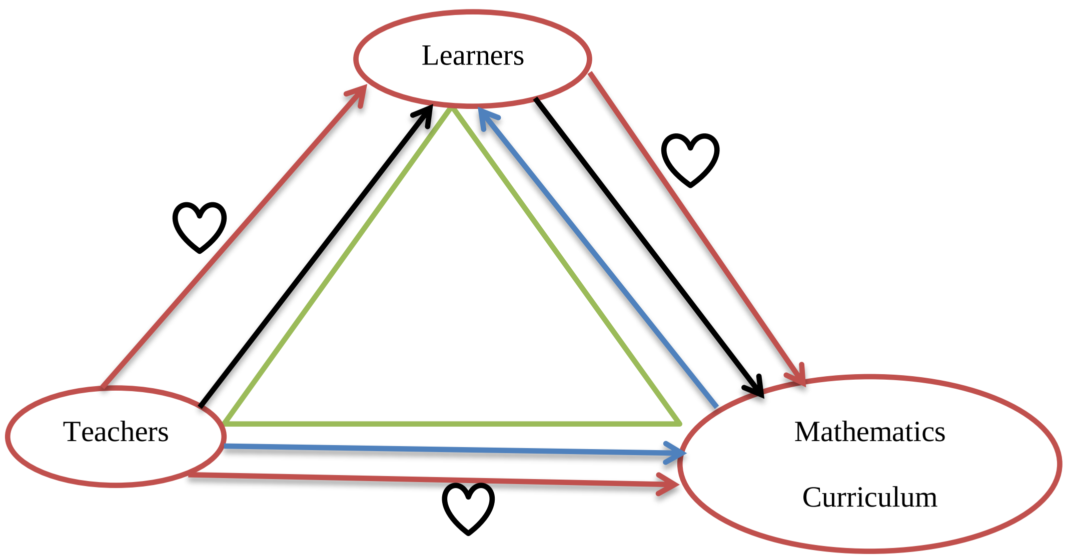


Figure 2. 1: Creative teaching pathways

Some say teachers must pay attention to the subject and teach their learners (the teacher must approach learners through mathematics, as indicated by the blue arrow in Fig 2.1). Others suggest that priority should be given to our learner's previous knowledge and interests and help them accordingly (the teacher should approach mathematics through learners looking at the black arrow). The researcher believes teachers should simultaneously consider learners' backgrounds and curriculum requirements (as indicated through the red arrow) and help learners engage in learning mathematics easily (♡).

Some researchers define creative teaching by giving priority to curriculum requirements. It necessitates the preparation of relevant curricula, lesson plans, and pedagogy that support learners learning in the best possible manner while allowing space for creative improvisation (Hadar & Tirosh, 2019; Maskur et al., 2020). Hence, according to Cremin (2019) and Anderson et al. (2022), creative teachers must be open to and support out-of-the-box thinking. In addition, (Mayer, 2019) defines creative teaching as an instructional technique that aims to assist learners in learning new material in ways that will allow them to apply what they have learned to new challenges.

Grainger, Barnes, and Scoffham (2004) define emphasizing the main participants, not the curriculum or the process. They define creative teaching as ''a collaborative enterprise involving engagement, reflection, and transformation, patterned at such a rate as to invite and encourage learning and the transfer of understanding from one context to another'' (p. 13). This view is supported by Sawyer (2019) and Cremin and Barnes (2018) in that creative teaching is a collaborative enterprise between teachers and learners. In making explicit the impulsive and collaborative nature of creative teaching, Sawyer (2019) explains the process as "disciplined improvisation" (p12).

This study's most pertinent definition of creative teaching focuses on the teacher's knowledge of both learners' backgrounds and secure and creative mathematics knowledge. Similar to this view, Khalid et al. (2020) hold the view that creative teaching in mathematics involves teachers' use of all their skills to plan, prepare, and teach imaginative, innovative, challenging, and unusual activities on the one hand, on the other hand they know the interest of their learners and adjust the curriculum depending on the learner's interest and without missing curriculum requirements. In addition, according to Meier, Gross, Vogel, and Grabner (2022), creative teaching is all about flexibility and overcoming fixation in teaching mathematics. Hence, mathematics teachers need training in several essential skills in creatively delivering the subject.

2.1.5 Why is Creativity needed in teaching mathematics?

The third-millennium job market is the driving force behind the need for creativity. Even though we do not know what the job market will look like in the future, it is predictable that it will need more creativity than it does nowadays. Before one century, in 1900, around 95% of employment was low-skilled and required employees to follow straightforward instructions created by others; currently, less than 10% of jobs fit this description (Sawyer, 2019). Our creative era will soon see the automation of all non-creative tasks. For example, Computers and robotics have replaced working-class factory occupations. Numerous managerial positions will soon be automated because of recent artificial intelligence (AI) advancements.

Sawyer (2019) asks learners two questions at the beginning of each semester; the first one is: *Did you ever get an A in a class, and then a month later, you had forgotten everything you had learned?* Moreover, the second one is: *Did you ever get an A in a class but did not understand anything you were learning?* According to Sawyer, almost all top learners raise their hands in both questions. According to studies, even the top learners struggle to retain what they have learned in school and often do not understand the material they were taught (Sawyer, 2019). This shallow knowledge is the outcome of traditional teaching methods. Even the best learners own shallow knowledge, which may only be memorized for tests.

In such a reality, the significance of cultivating creative teaching skills in teachers and creative knowledge in learners is visible. The best way to cultivate creativity in learners is to use innovative teaching strategies and teach creative knowledge. Learners understand what they are learning when they acquire creative knowledge. Creative knowledge is adaptable; they can use it in new contexts and outside the classroom. Creative knowledge equips learners to approach a question/task they have never encountered before with a deeper understanding of the subject matter (Sawyer, 2019; Raturi & Bhandari, 2022).

2.1.6 Is the skill of creative teaching teachable?

As discussed earlier, creativity is crucial to critical thinking, innovative teaching, and learning mathematics. It is the key to success and an essential skill for teaching, learning, and living in the third millennium (Trinanda & Yaswinda, 2022). According to Cilli-Turner, Turkey, Karakok, Savic, and Tang (2020), teachers at all levels have the potential to teach mathematics creatively, which can be reflected in several forms (e.g., in solving problems and posing new questions). Hitherto, there is little understanding of fruitful applications of creative teaching in teaching mathematics (Papadakis, Kalogiannakis & Zaranis, 2021) because there is no clear and consistent definition of creativity in effective mathematics teaching. According to Downing (1997), creative teaching skills are like 'needlepoint or archery'; they depend on inborn ability. All humans are not born with identical 'steady hands and keen eyes' to become experts in needlepoint or archery. This view is backed by Joubert (2001, p.21):

Creative teaching is an art. One cannot teach teachers didactically how to be creative; there is no fail-safe recipe or routine. Some strategies may help promote creative thinking, but teachers must develop a repertoire of skills to adapt to different situations.

In contrast to Joubert (2001), modern educational experts confirm that the skill of creative teaching is not inborn; it is personal development that can be achieved through practical training (Dai, 2020). Although all teachers are not born with identical brain skills, this inborn skill is eclipsed because most of our skills and experiences result from exposure to the proper training (Khalid et al., 2020). According to Anderson et al. (2022), creative teaching skill is not only inborn and rare; it is improved. Given the right setting, training, and encouragement, the average teacher possesses hidden or suppressed creative abilities capable of unfolding and growing. Virtually any teacher already possesses sufficient creativity to do quite an excellent job of creative teaching. This reality leads to the importance and centrality of creativity in teaching mathematics (Klien & Leikin, 2020). Hence, it is possible to cultivate creativity in each learner through proper teaching and in every teacher with good training. The skill of creative teaching is a personal development that could be done through well-planned and prepared continuous professional development (CPD).

2.2 Continuous Professional Development (CPD)

CPD in teaching refers to developing in-service teachers to exploit their maximum potential in executing their professional role after they complete their initial training (Hopia, Miettinen, Miettinen & Heino-Tolonen, 2019). Although it is difficult to forecast what education will look like in the future, it is undeniable that the future educational system requires higher cognitive skills than today. As social and technological changes are unprecedented and rapid, mathematics teachers must acquire new competencies or adapt existing ones to the changing conditions to prevent their skills from becoming obsolete (Rio & Newman, 2022). Hence, CPD should equip teachers with the skill of dealing with changes. In addition, it must equip teachers with the tools they need to learn new things or reinvent themselves continuously. They must be flexible, skilled, and creative teachers. Learners' and their communities' futures and hopes depend on teachers' capacities for self-improvement.

Sophisticated forms of teaching are needed to cope with changes in technological transformations and new skill demands. This teaching style should help learners develop capabilities including a deep understanding of contents, communication and collaboration, critical thinking, flexible problem-solving, and self-regulation (Rio & Newman, 2022). That is why high-quality CPD is a key element of almost all contemporary proposals for school reform.

According to Thurm and Barzel (2020), the professional development of mathematics teachers is considered a crucial component of all efforts to enhance teachers' methods of instruction and learners' academic achievement. Therefore, CPD should come with two changes. That is an improvement in teachers' practices which in turn must enhance learners learning (Rio & Newman, 2022). It is considered unsuccessful if either is incorrect—either the CPD miscarried to change instruction, or the reformed technique of instruction failed to advance learners learning (Moss & Brookhart, 2019). Improving teacher excellence at all phases of a teacher's occupation is thus a significant factor in cultivating the quality of education learners receive.

Mathematics teachers' professional development is not an easy practice; it is even more complex today. Teachers are expected to teach creatively and reinvent themselves daily with the new progress in the world of mathematics and the education system. The subject of mathematics is expanding continuously, and the ICT revolution comes with new challenges and opportunities. Doing this needs the integrated effort of politicians, administrators, experts, learners, and teachers.

2.2.1 Trends of Ethiopian CPD

The CPD program trend in Ethiopia is categorized into two types: Updating and Upgrading (Endale & Demessie, 2020; Mohammed & Gutema, 2021). 'Upgrading' is a vertical process that allows teachers to engage in further studies outside of their usual duties as teachers. Most of the time, this is done in a summer program, e.g., upgrading ‘‘a certificate to a diploma, a diploma to a first degree, or a first degree to a master's degree’’ (Endale & Demessie, 2020, p.1039). Whereas 'Updating' is a constant process where each qualified teacher participates throughout their professional role. It stresses subject content knowledge and pedagogy and improves classroom practice.

Updating CPD, which is this study's concern, has been effective since 2007 (Latchanna, Venkataramana & Garedew, 2019). This lifelong learning entails teachers engaging in 60 hours of professional development tasks yearly (Geletu, Mokennen & Mokennen, 2021). Every teacher in a school must participate at least sixty hours a year in specified CPD activities. Flexible use of these hours could be made to address the many CPD priorities that impact the work of the individual teacher or institution. The allocation of the sixty hours is up to each school, considering institutional, local, and national interests. The CPD module claims that dedicated and helpful colleagues in schools are the most effective and accessible human resources for CPD. If the school organising CPD lacks the required knowledge, skills, or experience, they may seek the assistance of an expert or organisation with the relevant experience and knowledge.

In the researcher's view, the CPD program has some deficiencies. Firstly, experienced teachers from the school are chosen to mentor novel teachers like they were mentored before. The researcher believes that through this process, schools do not show the required progress because the mentors may not have acquired the required skills when they were mentored before. Giving too much responsibility to experienced teachers may hinder identifying the fundamental challenges in the teacher's teaching skills and learners' achievement. CPD efforts that improved learners' learning were mostly built on ideas obtained via the involvement of outside experts

(Guskey & Yoon, 2009). None of the successful initiatives employed peer coaching, a train-the-trainer model, collaborative problem-solving, or any other kind of school-based CPD activities; it does not mean that these methods are useless. Instead, it only notes that there is currently a lack of compelling, reliable, and scientifically sound evidence supporting their efficacy (Guskey & Yoon, 2009).

Secondly, the concern of existing CPD for mathematics teachers is about efficiently teaching what is written in the textbook. A mathematics teacher has to teach the rules, formulas, and how to make a calculation using these fixed routines. As a result, secondary school mathematics teachers have enough knowledge to perform a calculation. They spent almost all of their classroom time making calculations that calculators could do. On the contrary, they lack conceptual understanding of the subject. They understand mathematics as a science of numbers with many rules and formulas to be memorized during calculations and detached from real-world conceptual problems (Gebremichael, 2019). In reality, modern mathematics has little connection with numbers. It is not the study of numbers or formulas but of life, pattern, and order (Devlin, 1996).

Third, no subject-specific professional development module was developed to help mathematics teachers by considering the nature of the subject. It is a 'one size fits all' type and has no space for creative teaching, even as a direction for the schools expected to exercise these modules. In contrast to MoE, the researcher believes that additional copies of subject-specific CPD modules on creative teaching and its strategies are necessary and urgent need in the 21st-century educational system.

Generally, today's Ethiopian secondary school mathematics teachers are trained in the traditional method of instruction. Consequently, they teach their learners how they were taught before. Additionally, the existing CPD program is a one-size-fits-all type. This kind of CPD is designed to ignore the motives and demands of teachers (Taddesse & Rao, 2022) and has limited potential to foster teacher learning. This limitation indicates that there is an urgent need to fill the gap between yesterday and today, and this could be done through continuous professional development, which enables teachers to equip the skill of creative teaching.

2.2.2 A Model of professional development for creative teaching

Countless professional development models are developed to exploit teachers' full potential during their professional roles. Some say a core feature of teachers' professional development and competence is the skill to assess learners' achievements effectively (Yangambi, 2021). Others claimed that CPD theories must consider cognitive and socio-cultural elements of learning (Vygotsky, 1978). In contrast, others did not suggest investing capital in developing new teachers' professional development. Instead, they recommend redefining what helping teachers means through professional development, evaluating the current professional development, and taking actions to enhance it for creative teaching. Although there are several professional development models, the researcher chooses training as an essential model for this study.

2.2.2.1 Training for Creative Teaching

This CPD training model promotes a technocratic, skills-based approach in which CPD enables teachers to demonstrate their competence by updating their abilities (Mwila et al., 2022). Typically, it is "delivered" to the teacher by an "expert," with the expert setting the agenda and the participant taking a passive position (Williams, Kamarulzaman, & Cuthrell, 2022). Training in this study is a model; trainee teachers often observe experts' demonstrations passively.

Teachers are supposed to put into practice what they have learned from the experts in seemingly appropriate contexts. Researchers distinguish between acquisition and performance because teachers do not perform everything they learn (Eun, 2019). During the creative teaching skill reproduction, the teacher receives feedback from the on-site trainer (expert) and can adjust their representation for future reference. For activities like creative teaching, self-observation is difficult; thus, feedback from others can be useful for self-evaluation.

The critical assumption in the training model is that some behaviours and techniques are worth replicating within the classroom. The other is that teachers can adapt their behaviour and learn to imitate classroom behaviours that were not part of their routine or toolkit before (Rio & Newman, 2022). Vygotsky (1978) especially identified the interplay between the expert and the less competent as the force behind development. The strategies, feedback, and discussion shared on the inter-mental plane become internalized with time and repeated interactions. The less skilled teacher ultimately uses the outcomes of dialogic encounters independently without receiving direct instruction from the expert. For instance, in the beginning, the less experienced teacher may want ongoing, prompt feedback from the expert regarding the use of particular instructional practices. With time, less experienced teachers begin to employ the strategies independently without external guidance.

2.2.2.2 Content of Training for Creative Teaching

The choice of content can make a massive difference in relevance to life today, (hence) to trainee teachers' engagement. Still, the most important thing is its connection to classroom lessons and how the topic is approached (Alemayehu, 2021). Many researchers indicate that their CPD programs fail due to the deficiency of a direct connection to teachers' classroom lessons. One supposition for the unsatisfactory outcomes of very intensive content-focused CPD, such as that investigated by Mann and Webb (2022), is that CPD is less effective when it does not assist teachers in implementing the knowledge or approaches into daily instructional routines and lessons. These studies recommend that when planning CPD, we should consider how easily CPD may be incorporated into teachers' daily lectures. Instead of leaving that problem to teachers when they return to the classroom, we should intentionally address alignment with lessons and provide assistance, direction, and practice for teachers to incorporate the material or pedagogy into their daily teaching.

2.2.2.3 'Two-eyed seeing' content-based CPD training

Relevant textbook content supports teaching creatively. Ethiopian secondary school mathematics textbooks are Western-based, with foreign and Ethiopian authors. These textbooks are not grounded in our society's understanding of mathematics. Hence, teachers and learners struggle with meaning-making (Gebremichael, 2019). Replacing these materials with Ethiopian-origin mathematics is unrealistic in the information age because most indigenous mathematics knowledge disappeared or stooled during colonization and is considered Western for owners of the knowledge.

Therefore, the best option is to bridge the gap between indigenous mathematics knowledge (out-of-school mathematics) and textbook mathematics through CPD. The influential metaphor "two-eyed seeing" (Hatcher, Bartlett, Marshall, & Marshall, 2009) stresses the importance of teachers training on Indigenous and Western mathematics strengths. It helps teachers deepen and broaden their understanding of mathematics from either knowledge (Meyer and Aikenhead, 2021).

2.2.2.4 Indigenous Mathematics Knowledge

Ethiopian learners currently studying in schools are learning the mathematics of mathematicians (Ayalew & Areaya, 2021). According to Nyoni (2020), today's African educational system is based on the idea that mathematics is neutral, culture-free, and objective. As a result, learners do not seem particularly interested in learning mathematics (Assen, 2020), which harms their academic performance (Wondem, Tesfamicael & Getahun, 2023). Reconstructing indigenous knowledge and incorporating it into the curriculum is a recent global endeavour (Jima, 2023).

Mathematics has been practised in every society from a time unremembered up to this third-millennium artificial intelligence era and obviously will be practised in the future. This idea aligns with Zaslavsky (1993, p.46), who says '*mathematical ideas and practices arose from the real needs and interests of people in all societies, in all parts of the world, in all eras*". Societies and individuals discover mathematics to communicate and solve difficulties they face in their day-to-day activities.

About 85% of Ethiopian society lives in rural areas, with over 80 ethnicities. Tradition, culture, myth, and religion significantly impact their lives. In such a setting, indigenous mathematics knowledge has an undeniable impact on society. Teachers and learners come to school with this knowledge as part of society. In cultivating and upgrading this knowledge, teachers and learners see the relevance of mathematics in their lives and understand where to apply it (Gebremichael, 2019). In addition, learners never search for solutions from the web for the local real-world assignments provided by their teachers. Instead, they try to solve by themselves, which is an important trend in nurturing creativity in learners. It is through this process that creative and responsible citizens can be cultivated. Therefore, a professional development program aiming to equip teachers with creative teaching skills must be rooted in indigenous mathematics knowledge of teachers' and learners' society and making connections between school and out-of-school mathematics (Gebre, Kassa & Wodeyesus, 2021).

Ethiopian traditional society does not even know the term mathematics, but they use it effectively to communicate, negotiate, and set fair prices. Instead of using paper and pencil to calculate, they know how to use stones or grains. Indigenous mathematics knowledge for CPD could be derived from different sources; some are listed below.

I) Documented indigenous mathematics knowledge

Western researchers had documented very little knowledge of Ethiopian indigenous mathematics. During colonization, westerners took not only our natural resources but also our knowledge. For instance, in 1940, when Ethiopia was fighting with Italy, Currie received a letter from Ethiopia that said:

The open-air marketplace of a rural village contains two rows of parallel holes, each about the size of half a grapefruit. Often, the holes are surrounded by people involved in an argument. At first, one might think that the holes are used for gambling and that some people are just sore losers. The fact is, however, that the holes are used to do multiplication and that the argument might well be over the price of the herd of goats (Currie, p.50).

For example, say a Farmer comes with a herd of 13 sheep for sale. The price of one sheep is, say, 90ETB (Ethiopian birr). The farmer and customer will not know the total price of the herd, so they call a shaman (a person considered to have unearthly knowledge). They ask him to set a price for the whole herd. The shaman digs two rows of pits in the dry earth. He puts 13 stones in the first hole on the left, one for each sheep. He puts half that, or 6, in the next half, 3, and 1 in the next. He keeps halving and dropping the fractions until the fourth hole has only one stone. On the right row, he puts 90 stones, the value of one sheep, in the first hole. He puts 180 in the next and doubles the exact times in the left column. He observes the left-hand side and decides whether the holes are good or evil. An even number of stones makes the holes evil, and an odd number makes them good. Three holes (containing 13, 3, and 1) are good. One hole (containing 6) is evil, and he ignores the stones in the right row parallel to 6, containing 180. After that, he added the stones on the right side, parallel to the good ones, containing 90, 360, and 720 stones. He adds those stones together. It is the exact value of the herd, 1170ETB

13	90
6	180
3	360
1	720

Now ignore all the even numbers from the left column; ignore the whole raw from both columns

13	90
—	—
3	360
1	720

Finally, add all the remaining doubled numbers, which are 90, 360, and 720. Moreover, their sum is 1170, which is the exact answer. It seems unbelievable that a system can ignore fractions and sometimes even throw away parts of the calculations and still come up with the correct answer. However, it works every time. The other most important thing is that the evil (even number) one is represented as '0', and the good (odd) one is represented by '1', leading to a binary representation of natural numbers. The binary representation of the number 13 is known from the above, 1101. It is done by assigning the odd one by '1' and even by '0' from bottom to top.

Ethiopia's indigenous and advanced system of mathematics is as sophisticated as today's modern computers. The words the researcher typed on the keyboard were written with the computer using diverse combinations of 0 and 1. The field of artificial intelligence is attempting to develop a new type of intelligence based only on computer binary script. Farmers in Ethiopia used this extraordinary and ancient method of multiplication. This knowledge might provide a strong foundation where Ethiopians could stand for more advanced thinking beyond this. Unfortunately, today's Ethiopians, including the researcher, are strange with this calculation system. Lack of documentation and attention makes it difficult to know our parent's logic behind this system.

The hole-in-hard dry earth and stone method is now used in Tigray as a game called 'Gebeta' (ገበጣ) in 'Tigrigna' local language, which means 'calculation.' There are many sites in Tigray with two-row holes in rocks, which were possibly used for this calculation in ancient times.

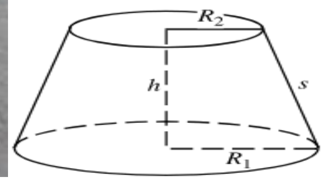
II) Undocumented Indigenous mathematics knowledge

Agriculture

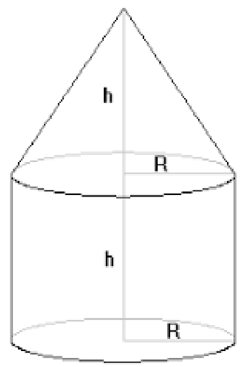
One of the undocumented sources of indigenous mathematics knowledge is the terms used in agriculture. The area of the agricultural field is measured in terms of how many pairs of oxen are needed to plague the whole area in a single day (ምውዐል ህንደይ ጽምዲ) (Tegegne, 2015). The field may need one, two, or more pairs of oxen to plough in one day; this is the field area that farmers communicate through. The farmers ask their buddy how many 'abyet' (ዑብየት) do you get from that particular land? "abyet" is a traditional grain container made from ox or cow skin and contains about 100kg of grain. When the land owner rents it to another farmer, there is a grain-sharing agreement between them. That is, maybe half-half (ልፍርቂ) to share equally $\frac{1}{2}:\frac{1}{2}$; one-third (ሲሶ) share in the ratio $\frac{1}{3}:\frac{2}{3}$; or one-fourth 'ርባዕ' they share $\frac{1}{4}:\frac{3}{4}$. It is about fractions that learners struggle to learn in school but have an apparent experience of their society.

Building and handcrafting

The other source of indigenous mathematics knowledge is traditional house designs and traditional household artefacts. These are all about shape (geometry), as seen in the sample figure below. It helps learners visualize geometrical objects around their natural setting and supports teachers and learners in mathematizing other works in their society (Weldeana, 2016).



Coffee pot seat Frustum (half of the coffee pot seat)



Traditional house ‘Gojo ‘ Cylindrical cone

Figure 2. 2: Geometrical representation of indigenous knowledge

In addition, weavers also measure the length of traditional cloth to be waived using their cubit (እመት) to decide the fair price for the owner of the cloth. Cubit is about half a meter. The kilogram measurement system was not known when deciding the fair price for honey. Therefore, the farmers decide the price of a single can; they mark the level of the honey on its original container, pour it into another container, and then measure how many cans of sorghum hold the original container of the honey up to the marked level. This system is used because measuring the honey using the can is bulky due to the honey’s sticky nature, and sorghum is simpler to measure.

Games, entertainment, and marketplace mathematics

Several probability games are played by cowboys, such as ‘shekut’ (ሸኩት). This game is mainly played to bring back animals (cows, goats, or sheep) when they go far from the grassing region. Cowboys assign a starting person, draw their fingers, and count the total number of fingers they draw. Following that, they start to count from the starting person to whom they agreed. The last person in the counting must bring back the animals. The other twin game that needs focus is if there are three cowboys, and five names are always represented for the five fingers they draw. They choose one name each and draw their finger; the probability that one of them will be a loser is not one-third but one-fifth. The cowboys may draw their fingers many times until they get the loser. These cowboys are not practising the probability of mathematicians but their society’s indigenous knowledge. However, in their school experience, they teach and learn the mathematics of mathematicians (Ayalew & Areaya, 2021)

Storytelling is another source of indigenous mathematics knowledge (Matthews, 2015) in teaching mathematics. Many mathematical problems are asked orally in society as a story; Parents ask their kids about dinner time as entertainment. For instance, If there are ten camels, the first camel carries one block of salt, the second two, the third three, and similarly, the tenth camel carries ten blocks of salt; how many salts do all carry? It is the concept of series we learned in school. Still, it was practised in our indigenous society long before modern schooling as camels were the primary means to transport salt from Denakil, Afar region, in Ethiopia.

The other one is the traditional marketplace mathematics (Madusise, 2022) practised today in rural areas. For example, if a villager buys 20kg of ‘teff’ (a grain used to make a local Ethiopian dish called ‘injera’) at 39.75 Birr per kg, they do not have a calculator machine to calculate the total price. Hence, they use the following system: first, they change 39.75 to 40 by adding 0.25 cents and make the multiplication simple $20 \times 40 = 800\ birr$. The next step is to subtract what they have been added before. $20 \times 0.25 = 5,\ \ 800 - 5 = 795$. That is $20 \times (39.75 + 0.25) - 20 \times 0.25,$ in school mathematics, we have used this system in changing quadratic equations to a perfect square.

Including such relevant knowledge in the CPD program helps motivate teachers and learners to give attention to mathematics practised in their societies. These help change the misconceptions and perceptions of teachers and learners that mathematics has little relevance to real life (Gebremichael, 2019). Teachers who teach creatively can use such kind of creative knowledge. These are useful to connect school geometry to reality and upgrade the indigenous multiplication method into the notion of powers and logarithm through an inverse operation as mentioned in the textbook knowledge (on expansion and inverse operation) below.

2.2.2.5 Textbook (western) Mathematics knowledge

Teachers teach what the textbooks write (Anwar, Choirudin, Ningsih, Dewi & Maseleno, 2019). Most of the textbooks' content on Western-based mathematics is about patterns, expansion, and inverse operation, and the CPD must focus on them. Meanwhile, regarding tasks in the textbooks, the role of CPD may be training teachers to tackle problems step by step using simple to complex methods. Opening up closed problems, showing alternative methods in solving questions, and simplifying complex mathematical concepts into simple, understandable ideas must be the concern of CPD. As teachers see these techniques from the expert in solving and posing problems, they are motivated to try other alternatives to solve and pose problems.

Number sense

Mathematical concepts are built upon previous math concepts. Number sense is the bedrock or the lower layer of all mathematics. The author of "Number, the Language of Science," Tobias Dantzig, emphasized the significance of this basic form of numerical intuition: "Man, even in the lower stages of development, possesses a faculty which, for want of a better name, I shall call *Number Sense.* This faculty permits him to recognize that something has changed in a small collection when, without his direct knowledge, an object has been removed or added to the collection" (Dantzig, 2005, p.20). Animals possess at least an approximate number system (Clarke & Beck, 2021). Likewise, 19th-century mathematician Leopold Kronecker once stated, "God made the integers; all else is the work of man." Kronnecker's idea was that numbers are the foundation of all mathematics. Even modern disciplines of mathematics are not heavily reliant on numbers.

Teachers and learners are frequently disconnected from reality and the intuitive nature of mathematics (Thurston, 2005). They were discouraged from thinking for themselves and expressing their thoughts. Instead, learners strive to understand what routines they should learn. They always inquire if it will be on the test whenever there is a deviation in the classroom from the syllabus or the material. One good example concerning number sense is (Rich & Yadav, 2020), who wrote that US learners were requested to solve the exercise below.

1128 Soldiers must bused to a base; each bus holds 36 soldiers. How Many buses are needed? The answer is 32, and most learners correctly compute the division; however, the meaningless 31.33 was the most often given response by US students since $\frac{1128}{36} = 31.33$. This example indicates the learners' lack of number sense. They use the rule of long division, how to divide and apply it here. They were unaware that integers are needed when ordering buses and should round up to 32. Similar experimental research was done by Palm (as cited in Vos, 2018), who found learners lack number sense.

The other example is 'The Seventeen Camels and Three Sons.'
A father left three sons and seventeen camels. Based on his will, the oldest gets half of them, the second one receives one-third of the camels, and the last son gets one-ninth. How many camels will each of them get?

The number 17 is prime; it can not divided other than to '1' and itself like other primes. Most of those who pass through formal education use the complex and meaningless way to solve it, that is $\frac{1}{2}(17)$, $\frac{1}{3}$ (17), and $\frac{1}{9}(17)$. Such kinds of problems are solved by those who use number sense; a wise man who uses number sense conceptually and flexibly adds one camel from himself and makes them 18. The eldest one gets$\left(\frac{1}{2}18 = 9\right)$, the second ($\frac{1}{3}18 = 6$), whereas the last one gets ($\frac{1}{9}18 = 2$) and total 9+6+2=17 correct; the wise man takes his camel. These examples are what a number sense means.

The above example shows that every mathematical problem does not have a fixed routine to follow; it needs flexible thinking. There is no rule or formula for solving such problems but our intuition. In mathematical practice, the intuitive is everywhere (Hamami, 2022). If teachers and learners use only formulas and procedures to solve mathematical problems, they deny unconsciously using their minds. Even animals know the number of their offspring. If they lose one of them, they rush to find it; this is the intuitive nature of animals. Hence, CPD must cultivate the intuitive nature of mathematics teachers by encouraging them to use their intuition in problem-solving and posing new ones.

Expansion and inverse operation

Most mathematical creativity in secondary school comes from expansion (boundary-pushing) and inverse operations (Leikin, 2020). For example, we know that $2^4 = 16$ from the previous topic on indigenous knowledge. Now, we can ask if there is any possibility that the inverse operation $2^{16} = 4,\ 2^{(2^4)} = 4,$ hold? In this manner, teachers can introduce the notion of the logarithm to their learners. It has been upgraded to $\log_2 16 = 4$ because $\log_2 16 = \log_2 2^4 = 4 \log_2 2 = 4$. The number system is also all about expansion: Natural numbers (counting numbers) to whole numbers (including '0'), to integers, and then to rational, irrational, and real numbers, up to complex numbers (to solve $x^2 = -1$) is all about expansion.

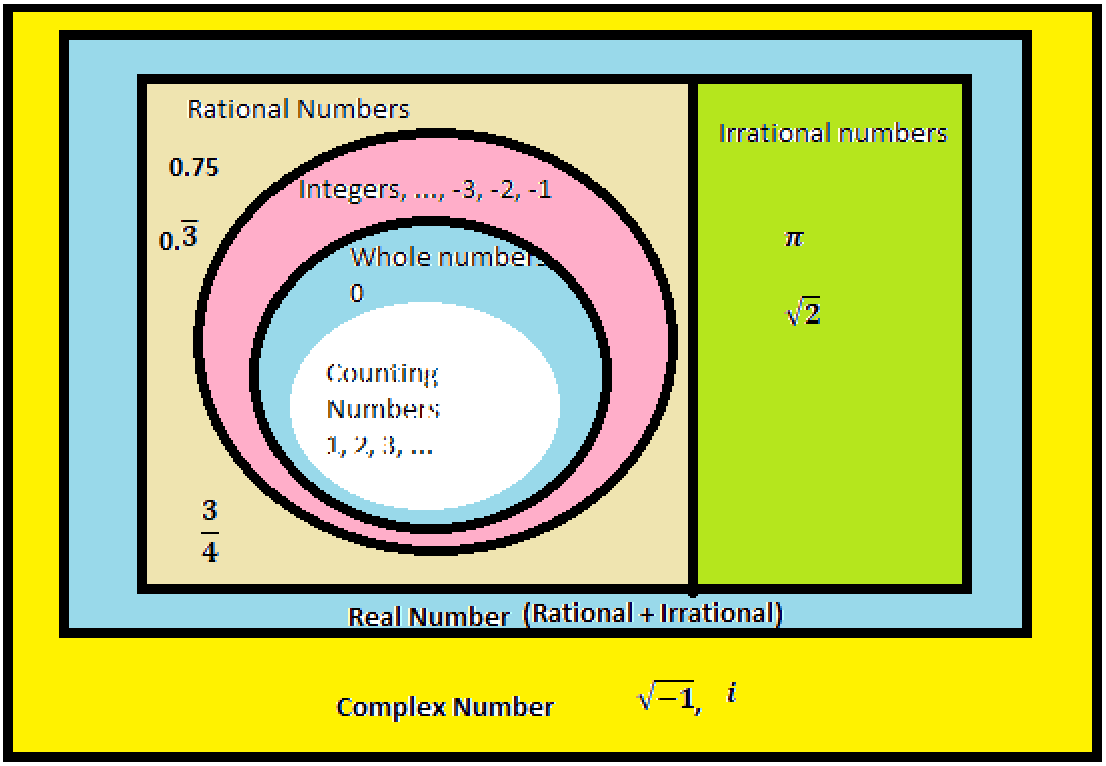


Figure 2. 3: Number systems

Well-known mathematician Fermat expands the Pythagoras theorem, which says for a right angle triangle with sides a, b and hypotenuse c, is $a^2 + b^2 = c^2$, to the theorem, there is no whole-number solution to $a^n + b^n = c^n$, for n>2, which Andrew Wiles later solved. Hence, at the secondary school level, number sense, inverse operation, and expansion are some concepts of basic-level creative teaching.

Therefore, the other concern of CPD for creative teaching should be showing teachers how mathematical concepts evolve through expansion and inverse operation. When teachers are exposed to such reality, they motivate their learners to push existing boundaries of mathematics. In these ways, previous math scholars shattered the glass ceiling of fixations in mathematics (Havoold, 2018).

Training on pattern-making

In ancient times, mathematics was all about numbers. They used specific numbers to describe mathematical ideas. For example, as stated in Devlin (1994), The following instructions for determining the volume of a specific truncated square pyramid appear in the so-called Moscow papyrus, an Egyptian text written in 1850 B.C.

If you are told: a truncated pyramid of 6 for the vertical height by 4 on the base by 2 on the top. You are to square this 4, result 16. You are to double 4, result 8. You are to square 2, result 4. You are to add the 16, the 8 and the 4, result 28. You are to take a third of 6, result 2. You are to take 28 twice, result 56. You will find it right.

This instruction is a specific volume calculation method for a single truncated pyramid. There is such kind of instruction for each pyramid. However, today, mathematics provides what is general about the volume of a truncated pyramid. The above instruction is translated to the algebraic expression (pattern) as if the truncated pyramid has a base side equal to a, top sides equal to b, and a height h. Then, its volume is given by the formula:

$v = \frac{1}{3}h(a^2 + ab + b^2)$This is a general formula that works for all truncated square pyramids.

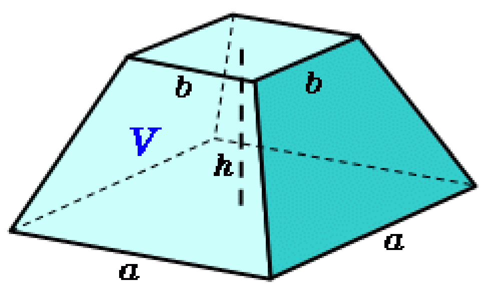


Figure 2. 4: A truncated pyramid

The modern view of mathematics does not consider the subject to be a science of numbers but a science of patterns (Benjamin & Quinn, 2022). Most secondary school mathematics texts are about patterns of numbers, patterns of shape, patterns of reasoning and communication, patterns of motion, and patterns of symmetry and regularity. These patterns are general techniques used to solve similar problems. For example, Pythagoras's theorem, commutatively of addition and multiplication, and the formula for areas of rectangles, circles, and squares all generally happen all the time. When we use a formula to solve a circle's area, it applies to all circles irrespective of their size.

Pattern-making encourages mathematical creativity and creative teaching in secondary schools. When teachers and learners are exposed to seeing mathematics as patterns instead of methods and rules, they become motivated to identify particular patterns in mathematics topics (Devlin, 2018). It encourages teachers to think more about what they were trained in; what is general about the situation? For instance, training of patterns of the sequence of even numbers written as $\{2n\}_{n=1}^{\infty}$ and odd numbers $\{2n+1\}_{n=0}^{\infty}$. It should lead to finding the pattern of the sequence of prime numbers. Hence, encouraging teachers and learners to find a pattern for the sequence of prime numbers, which is not solved yet, leads to creativity.

Connecting the tasks of the text to reality

Connection-making is the core concept of creative teaching (Rim, 2019). Learners fear and fail in mathematics mainly because of its abstract nature and perceived irrelevance to the real world (Gebremikael, 2019). This impression is a reflection of what they have learned in school. The education system unconsciously detaches mathematics from the lives of teachers and learners. Teaching mathematics must be relevant to learners' interests, concerns, and socio-cultural backgrounds. To that end, creative teachers must connect the course's content to their learners' lives.

Secondary school teachers were taught to teach unrealistic content; therefore, they need training in correcting textbook mistakes and connection-making. When teachers make and see connections between school and real-world mathematics, they understand real mathematics and become considerably more interested in the topic. Concerning the significance of connecting mathematics to the real world in teaching, Woods concluded that:

The higher the relevance of teaching to children's lives, worlds, cultures, and interests, the more likely pupils will have control of their learning processes. Relevance aids identification, motivation, excitement, and enthusiasm. Control, in turn, leads to ownership of the knowledge that results. If relevance, control, and ownership apply, the greater the chance of creative *learning resulting – something new is created, and there is significant change or 'transformation' in the pupil – i.e., innovation.*

(Woods 2002, p. 7)

Most of the time, curriculum standards do not work on connection-making, as they present mathematics as a collection of unrelated topics. Nevertheless, the training program must reinstate the connections by continuously talking about and valuing them and encouraging teachers to reflect on and discuss connections. Exploring new perspectives on mathematical connections should also be fostered in learners. Stigler and Hiebert (2004) say:

A focus on teaching must avoid the temptation to consider only the superficial aspects of teaching: the organization, tools, curriculum content, and textbooks. The cultural activity of teaching, how the teacher and students interact about the subject, can be more potent than the curriculum materials that the teachers use. (p. 16)

The textbook's content is essential in directing teachers and learners to make connections. Therefore, textbook authors must make mathematics exciting and relevant to everyday life. Unfortunately, instead of representing reality, Ethiopian textbook authors put mathematics into what Boaler (2015) called "pseudo contexts." Learners and teachers spent their time struggling with fake real-world questions that were far from reality (see Appendix A). Boaler (2015, p.297) describes this context: ''Many students know that when they walk into math class, they are walking into Mathland, a strange and mysterious place that requires them to leave their common sense at the door.'' Training teachers for creative teaching must help to adjust irrelevant textbook tasks.

Train more on modelling problems, not calculation.

Trainers should assign a real-world problem to their trainees. The trainee teachers must usually model the problem and do some calculations; after that, they need to check if their model solves the problem or needs further improvement. In Ethiopian secondary schools, teachers spend almost all their time in math classrooms performing calculations. That could be done by calculators or computers efficiently and without mistakes when learners should be focusing on the other three aspects of mathematics: creating models, improving them, and applying them to solve real-world problems (Boaler, Brown, LaMar, Leshin, & Selbach-Allen, 2022).

These enable teachers to challenge learners to take a problem from the real world based on real-world data and constraints and to solve it using mathematics. Here, learners are expected to model the situation. For example, instead of asking to solve, $\begin{cases} x - y = 2 \\ x - 2y = -3 \end{cases}$ Simultaneously, ask: Aliza and Juju each have a basket of eggs, but they do not know how many eggs each basket contains. If Aliza gives Juju one of her eggs, they shall have the same number. On the other hand, if Juju were to give Aliza one of her eggs, then Aliza would have twice as many as Juju. How many eggs does this mean they each had initially?

If we let the number of eggs in Aliza's basket 'x' and Juju' y', then

$x - 1 = y + 1$; $x + 1 = 2(y - 1)$ Which means $\begin{cases} x - y = 2 \\ x - 2y = -3 \end{cases}$

In addition, Livy, Muir, and Sullivan (2018) conclude that mathematics problems must be challenging for learners to give them chances for creativity, learning, and making connections. It does not imply increasing the challenge's strength, which would frustrate learners. Instead, it means learners should understand the idea, but it must be challenging. One good example is finding the pattern of prime numbers; it is simple for every student to comprehend the idea but challenging to solve.

Train on how to open up closed problems.

The mathematics textbook is staffed with predetermined equations; almost all questions are closed. They have only one correct solution. The job of teachers and learners is to solve these predetermined questions, which can be solved quickly and without mistakes by applications or calculators. It makes sense that some questions may be closed with a single correct solution. However, even if they were employed, these questions would have to be infrequent for learners to have a solid understanding of mathematics. Mathematical exercises should provide lots of room for learning (Brandt & Eagleman, 2017). They should let learners explore, create, and learn rather than forcing them to provide answers. Most mathematics questions can be opened up; this must be the concern of the CPD training. Here is an example of ways to open math tasks:

Instead of asking learners to determine the area of a 4 by 16 rectangle, ask them to find the sides of a rectangle whose area is $64u^2$, learners will come from different paths to find the sides whose area is $64\ u^2$.

When teachers direct learners to solve the above kind of open mathematical problems, they are encouraged to see mathematics as a creative subject and positioned as an inquirer. They no longer find an answer but explore ideas, make connections, and value creativity and learning. In addition, they are also studying formal mathematics and the procedures and formulas outlined in the curricular requirements. This method cultivates creativity, autonomy, and a deeper conceptual understanding of the subject (Berisha & Bytyqi, 2020) in both learners and teachers, as learners come with different brain pathways in solving such kinds of open tasks.

Show alternative techniques

Every problem cannot be opened up; some tasks may have only one answer. In such kinds of situations, teachers should show alternative options. As cited in Brandt and Eagleman (2017), Richard Feynman, a famous physicist, was invited to assess mathematics textbooks for the California State Curriculum Committee in 1965 ("18 feet of shelf space, 500 pounds of books!" he criticised in his report). He believed the way maths is taught in the present era, where teachers teach learners only one problem-solving method, is wrong. Inspiring learners to travel from the hive at various distances is a good tactic when he promotes alternative problem-solving techniques. According to him, teachers should instruct learners to explore all available options in order to arrive at the best solution:

We want arithmetic textbooks not to teach a particular way of doing every problem but, instead, to teach the original problem and to leave much greater freedom in obtaining the answer. We must remove the rigidity of thought … We must leave freedom for the mind to wander about in trying to solve problems … The successful user of mathematics is practically an inventor of new ways of obtaining answers in given situations.

(Feyman, cited in Brandt & Eagleman, 2017, p.223)

A sample example of alternative techniques for solving quadratic equations is presented in Appendix B.

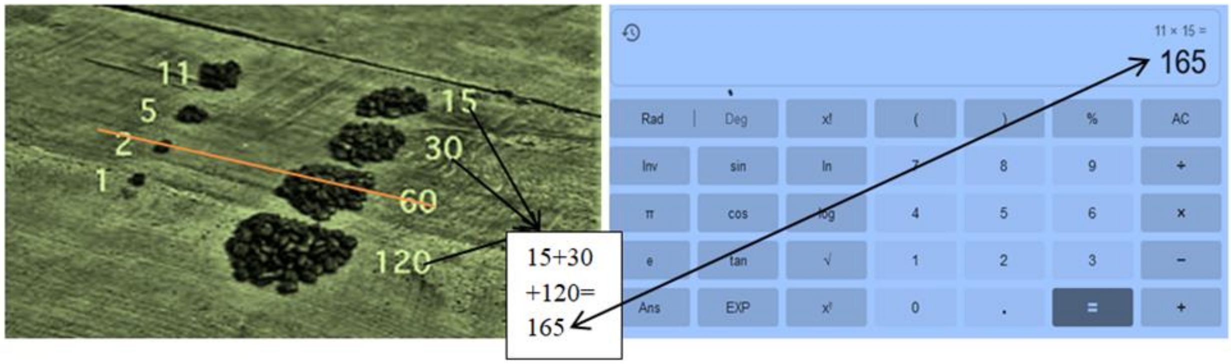
Draw problems to visualize and solve them.

Mathematical tasks become easy to understand and solve the problem when visualized or sketched. Drawing problems connects abstract and real-world contexts and helps teachers and learners realize and solve the problem (Kang et al., 2020). Helping teachers to think visually about maths is essential since doing so opens up new brain pathways for knowledge and use. Teachers should be asked to draw ideas, methods, solutions, and problems during the CPD; in turn, teachers should always ask learners to link visual concepts with numerical or algebraic approaches and answers. A key mathematical skill employed by mathematicians and expert problem solvers is the ability to represent mathematical concepts in various ways. Mathematicians can illustrate their concepts in various ways, including graphs, tables, words, drawings, and doodles. Mirzakhani explains how to approach a challenging mathematical problem:

"You do not want to write down all the details …But the process of drawing something helps you somehow to stay connected." Mirzakhani claimed that whenever Anahita, her 3-year-old daughter, sees the mathematician drawing, she frequently says, "Oh, Mommy is painting again!". "Maybe she thinks I am a painter." (Klarreich, 2014)

The ideal method to tackle complex mathematical problems is to draw, visualize, and understand them. Drawing a problem may be difficult for teachers who do not use it at the beginning, but after they are trained to use it, it is helpful, and they will use it (see Appendix C).

Expose to technology



Stone Age multiplication (slow, bulky) Third-millennium multiplication (fast and easy)

Figure 2. 5: Multiplication Tools

The basic principles are the same (both use binary multiplication rules) to multiply 11 by 15; the difference is the tool. Mathematics teachers should be updated with new mathematical tools to teach 21st-century learners.

Some mathematical problems and concepts may not be understandable using only paper and pencil. Geometry Pad, hyper calculators, Hawgent, and GeoGebra, help teachers and learners to create their dynamic demos, inspiring learners, for instance, to study geometric and algebraic concepts like visualize the behaviour of linear equations $y = ax + b$, quadratic equations $y = ax^2 + b$ and trigonometric ratios, animatedly and visually. When mathematical concepts and problems are investigated using technology, they become multimodal, interactive, energetic, and process-oriented (Freiman & Tassell, 2018). This trend could lead to essential mathematical innovation while empowering deeper understanding through reflection and critical thinking.

While many studies have used the software described above to improve mathematics instruction, they have mostly been concerned with creating instructional material and enhancing learners' skills. In addition, while numerous studies have looked at its application with learners, none have utilized it to enhance aspiring maths teachers' inventiveness and teaching skills.

2.2.3 Implications of a Model of professional development for this study

The goal of this study is to empower teachers with the skill of creative teaching. Choosing a professional development model that fits the study's purpose is vital for the study's success. The researcher chose training as a model for the skill development of teachers. Now, we are going to see its implications for this study.

Practical training for creative teaching is the source of self-efficacy and motivation for trainee teachers (Eun, 2019). When the expert trains the trainee teachers, they recognize that the expert is a mathematician like themselves. What the expert trains is also about what they have taught for several years; hence, teachers think they have most of what the expert has and can perform like the expert with guidance. Teachers understand that the skill of creative teaching is teachable, and every one of them can teach creatively with determination and hard work. Teachers use all they have to master this skill and put it into practice (Anderson et al., 2022). Teachers believe that experts are like themselves but approach mathematics unusually and creatively. Therefore, they are motivated to exert more effort in the face of challenges to master the skill.

Teachers with a strong feeling of efficacy are more tolerant than less efficacious teachers and are more willing to work with learners with learning issues (Chen, 2019). When they work to understand and incorporate unusual teaching strategies in their classrooms, they are more inclined to accept change as a necessary component of their development process (Eun, 2019). Additionally, efficacious teachers are more eager to experiment with and use challenging and creative teaching methods and materials (Choong, Ng, Ai Na & Tan, 2020). When faced with failures, they employ various coping mechanisms to control their emotional anguish and look for even more potent cognitive techniques to handle the work demands (Eun, 2019).

2.3 Theoretical framework

This portion presents the theoretical framework used to investigate the study's central research question: To what extent does the existing continuous professional development program equip secondary school mathematics teachers with the skill of creative teaching? This study aims to investigate mathematics teachers' professional development for creative teaching. Woods's (1990) features of creative teaching and Cremin's (2009) dimension of creative teaching, taken together, provide a theoretical framework for this study. Cremin (2009) claims that all research on creative teaching addresses a distinct part of the three dimensions of creative practice. These are personal quality, pedagogy, and classroom ethos. Hence, the researcher discusses Wood's features of creative teaching in terms of Cremin's dimensions of creative teaching.

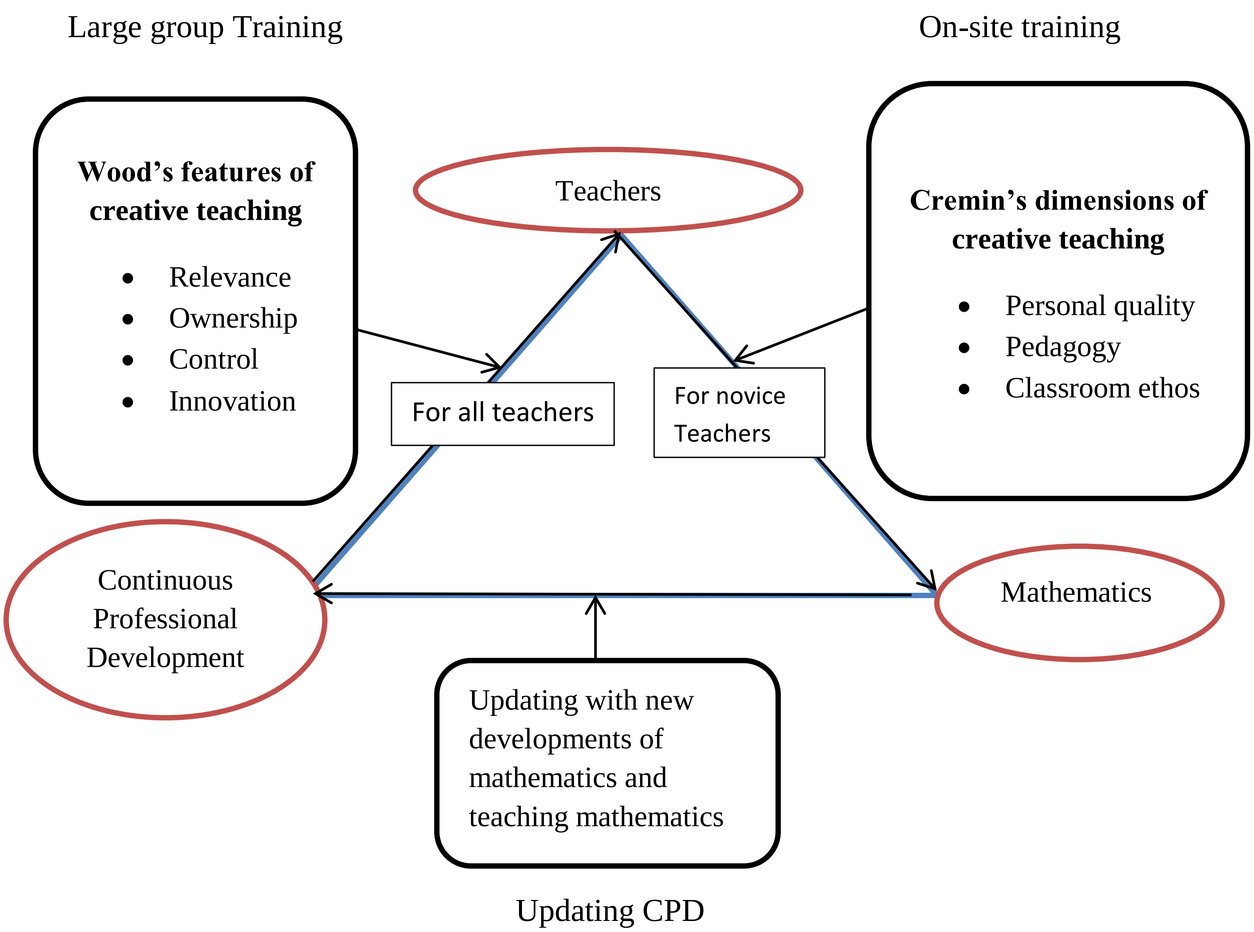


Figure 2. 6: A proposed model of professional development for creative teaching

Teachers should be trained on Wood's features of creative teaching in a large group. This group training should be followed by on-site training, especially for novice teachers using Cremin's dimensions of creative teaching as a framework. From the on-site training, professional development experts may get important input for further improvement in designing CPD for creative teaching.

2.3.1 Woods features in terms of Cremin's dimensions of creative teaching

According to Woods (1990), creative instruction has four key features: relevance, ownership, control, and innovation. The analysis of Woods's four features of creative teaching depends on Cremin's three dimensions of creative teaching see Table 2.1. According to Cremin (2009), the dimensions that define a teacher's creative teaching practice are personal qualities, pedagogical practice, and classroom ethos. In more expression, Personal quality, the traits of innovative teachers; pedagogical practice, the instructional techniques applied by creative teachers; and classroom ethos, the physical, social, and emotional environment designed for creative teaching.

Wood's (1990) features of creative teaching are rooted in the constructivism theory, in that the starting point of instruction should be relevant, i.e., familiar to teachers and learners. One of the two giants in constructivism theory is Piaget (1964), who believes individuals make meanings, interpret and construct knowledge and skills, and learn best based on their experience. According to Piaget (1973), teachers must customize the curriculum to the learners (Relevance) and try to personalize instruction as far as they can (Control). The large group must effectively disband as the only classroom unit; learners should frequently work on individual projects and be free to learn (Ownership). Piaget and Inhelder (1969) suggest that innovation is the most essential and significant feature of teaching and learning. Piaget states that the primary objective of education is to create individuals skilled in discovering new ideas and doing novel things rather than merely echoing what was done in the past. These ideas are in line with Wood's fourth feature, innovation.

Locating mathematics in the socio-cultural sphere means that it is human (Dominikus, Udil, Nubatonis, & Blegur, 2023). It makes no sense to talk about mathematics that existed before or after the human species (Hersh, 1998). Vygotsky concluded that ''any higher mental function was external and social before it was internal. It was once a social relationship between two people'' (Vygotsky, 1960, p. 197). Ownership of teaching described in Wood's features of creative teaching is the result of the internalization of creative teaching experiences.

Vygotsky considers that one essential aspect of development is the skill to control and direct one's behaviour, which is made possible through internalization. Creative teachers have control of their behaviours, pedagogy, and classroom ethos. They decide which approaches to use, what strategies to combine, and when to use them (Habibi, Yusop, & Razak, 2020). Innovative teachers can also develop and use opportunities and possibilities to teach creatively (innovation). Now, we will see each feature of creative teaching in detail.

Table 2. 1: Creative teaching matrix

		Dimensions of creative teaching		
		personal characteristics	**pedagogical practices**	**classroom ethos**
Features of creative teaching	**Ownership**	Subject matter knowledge	Owners of creative knowledge	Shared responsibility
	Relevance	Knowledge of learners' background	Connection making	Collaboration
	Control	Responsive to learners' ideas	Questioning stance	Time to struggle
	Innovation	Awareness of being creative	The flexibility of teaching styles	Value learner's unusual ideas

2.3.1.1 Ownership

Personal quality: In creative teaching, teachers must possess a secure and in-depth understanding of mathematics. To teach properly, teachers must have a deep understanding of the mathematical concepts of their subject (Cubero, 2022). This knowledge is observed in their confidence in handling questions raised by learners. Confidence, in turn, leads to having internal standards, regulations, and directions, and they are not acting like weather vans. Such teachers are not concerned with the expectations of colleagues and authorities but with their learner's understanding and do not fear anyone by being different. They are risk takers, independent, and owners of creative knowledge. In addition, they also have a strong sense of passion and dedication to their profession and are persistent and resilient in the face of difficulties (Fabelico & Afalla, 2020).

Pedagogically: Teachers should not act like information (knowledge) transmitting machines. The creative knowledge they are concerned with producing and constructing in learners must be integrated into their lives. It must be part of their knowledge as applied to their classrooms' social circumstances and learners' social backgrounds. When it is their knowledge, it will be adaptable knowledge that could be applied to new situations, such as solving learners' unexpected problems. Mathematics teachers should show considerable ownership concerning planning, teaching, and evaluating (Cremin, 2009). They must demonstrate a strong sense of professional autonomy in the classroom, be adaptable and self-assured, and communicate their intention to co-construct a curriculum that draws on the interests of the learners as well as their social and cultural capital in addition to the curriculum's standards.

Classroom ethos: The innovative professionals' classroom ethos should reflect the feeling of ownership as learners must share responsibility for designing their learning. Learners must be treated as mathematicians expected to contribute and encouraged to use their intuition. It entails developing a school setting "in which students are encouraged to debate and question the validity of… approaches to problems…, be encouraged to generalize the problem and the solution, as well as pose a class of analogous problems" (Sriraman, 2005, p. 28). The classroom ethos must enable learners to solve and pose new tasks and learn for themselves rather than for the teacher, examiner, or society (Woods, Boyle & Hubbard, 1999).

2.3.1.2 Relevance

Personal quality: Mathematics teachers should know their learners' interests, backgrounds, and cultures. Knowledge of learners' backgrounds helps to connect school mathematics to learners' authentic lives, as connection-making is central to creative teaching. Teachers should know that when learners find mathematics relevant to their lives, it will be simple to understand, retain, and contribute to their learning. So teachers can use their imagination to connect the content of mathematics to the lives of their learners only if they know their learner's backgrounds. As noted by Jeffrey & Woods (2003), relevant teaching consists of learners' acknowledgement of and understanding of such teaching through a feeling of togetherness with the teacher and responsiveness to the teacher's method.

Pedagogically: The beginning of the teaching experience must be relevant and familiar to teachers and learners (Abdulrahim & Orosco, 2020). Relevant teaching helps them to become easily engaged in teaching and learning practice. LI and Schoenfeld (2019) state that Mathematics must be grounded in reality and considered a human endeavour. In addition, teachers must go beyond subject boundaries and frequently reference the world beyond the school gate (Cremin, 2009). How is a subject like mathematics, which is heavily theoretical, linked to everyday life? Real-world word problems are a typical way to accomplish this (Raturi & Bhandari, 2022).

Classroom ethos: Teachers should create a working-together environment by adjusting the curriculum in response to learners' intentions. Teachers should give learners time to think deeply, explore previous knowledge, draw connections, and provide opportunities to collaborate and broaden their viewpoints. This environment encourages learners to make connections in their learning between subjects and within subjects and create connections with their lives outside school. This relaxed yet focused atmosphere fosters creative thinking and connections among mathematical concepts in solving and posing problems (Boaler, 2015).

2.3.1.3 Control

Personal quality: Teachers must be responsive to learners' situations. A study by Tsai (2012) shows that creative teachers should be open to learners' ideas and opinions. When leading their learners, they must use diverse patterns, rhythm, pace, and teaching philosophies throughout a session (Kundu, Bej & Rice, 2021). Creative teaching demands flexibility to be responsive to different learning methods, open to learners' ideas, questions, and reactions, and leave space for uncertainty (Vermote et al., 2020). Additionally, they must know that their body gestures, facial expressions, and tone of voice are essential because they indicate attention and have a significant moral influence on the learners.

Pedagogically: Teachers should use learner-centred instruction techniques. They start the lesson by asking questions and do not rush to answer every problem alone as they are not solution manuals. Questioning stance helps learners use their intuition and the teacher to get direction on how learners could understand the topic best. Teachers get multiple brain pathways in solving a single concept or problem (Hong et al., 2021). In doing so, teachers should not act as lecturers but as facilitators who frame *floor-low and ceiling-high* challenges and help with metacognition, self-reflection, and group discussion (Wong et al., 2022). According to Boaler, Brown, Lamar, Leshin, and Selbach-Allen (2022), having a low floor means the ideas are accessible to all. Having a high ceiling means learners can develop their thoughts to great levels. They opened up closed problems and concepts. It is essential because it allows for various learning styles and offers learners several access points during the class throughout the lesson.

Classroom ethos: The teacher and learners must interact with one another in the classroom as co-learners and participants, creating a collaborative learning environment. “Working alongside their learners, [teachers] were both participants and spectators in the process of meaning construction, demonstrating their independence from more traditional patterns of classroom discourse” (Grainger, Barnes, & Scoffham, 2004, p.18). Learners are encouraged to work on challenging but not frustrating problems, take risks, and create a conducive environment to struggle and fail, yet still feel good about working on difficult questions. Teachers avoid the “failure” idea so that they honour learners' thinking even when learners come up with entirely wrong answers. Such an environment helps learners use their intuition and imagination to guess possibilities.

2.3.1.4 Innovation

Personal quality: All teachers are innovative in several ways in their teaching lives, even though they might not often consider themselves innovative (Cremin, 2009). Teachers should be aware of being creative because innovation belongs to the teacher who cares about it. This innovation could be the teacher's or another person's idea modified for a different teaching environment. A teaching innovation appears when previously known elements are combined in a novel way or when a new element is added to the existing context. Teachers should be ready to learn about innovative teaching, take risks, and keep open to novel concepts. They should share any innovative practices they experiment with or create and must possess technological competence (Asad, Hussain, Wadho, Khand & Churi, 2021).

Pedagogically, creative teaching is the method of guiding creative learning. Learners possess a wide diversity of learning preferences. This diversity necessitates teachers to deliver according to learners' needs (Cubero, 2022). Hence, teachers must tailor the material and methodology according to learners' interests, prior knowledge, and current skills. A study by Asad et al. (2021)

shows that an inventive teacher is aware of incorporating modern educational tools to strengthen reasoning, foster critical thinking, and broaden and deepen learner comprehension. Using innovative approaches, acting spontaneously, and adjusting focus during sessions in response to learners' interests and questions, such teachers model flexibility and creativity, thus moderating the gap between the planned and the lived. Teachers leave space for ambiguity and the unknown when learners are perceived as creative thinkers. Teachers should have significant creative confidence in building on unexpected contributions or queries, fostering the learners' autonomy.

Classroom ethos: A study conducted by Godwin-Jones (2019) indicates that classrooms should offer choices of learning resources for learners whenever possible, as a human being is wired for free will. It helps learners to come up with novel ideas. Teachers should recognize learners' original and innovative ideas and elements to help them appreciate their creative abilities. In addition, these teachers aim to spotlight and publicize the learner's original and alternate work through displays, presentations, and assemblies (Vens, 2019). Learners should be allowed to utilize intuition to perform random guessing.

2.3.2 The role of Wood's Features of creative teaching and Cremin's Dimensions of creative teaching on professional development for creative teaching

Sternberg (2015) has concluded that "There are hundreds of books and thousands of articles on how to teach….. creatively. If one walks into a classroom, however, one is not likely to see much teaching for creative thinking" (p. 115). For creativity to be successfully implemented, strategic and relevant teacher training is required. Wood's features of creative teaching provide detailed information that creative teachers should possess during their professional careers. Wood (1990) writes that teaching mathematics should be relevant to both teachers and learners: teachers must be subject owners and control the classroom activities, leading to creative teaching. Cremin (2009) comes with the dimensions of creative teaching: personal quality, pedagogical practice, and classroom ethos. Creative teaching training discusses various characteristics of these three dimensions (Cremin, 2009). Therefore, the combination of the works of Wood and Cremin is helpful for professional development experts. They provide a comprehensive framework to train mathematics teachers in practicable activities for creative teaching.

2.5 Chapter Summary

A review of the related literature has been conducted in this chapter. The definitions of the term creativity in general, creativity in teaching mathematics, its historical value, and its definition in teaching mathematics have been clarified. The main focus of the study, the skill of creative teaching, its features, and how secondary school mathematics teachers can acquire this skill through CPD, was discussed. Trends of Ethiopian CPD have been investigated. In the theoretical framework, two theories (Wood's features of creative teaching and Cremin's dimensions of creative teaching) have been used as a lens for the study. Chapter three presents the methodological approach and the data collection methods employed for this study.

Chapter 3: Research design and methodology

3.0 Introduction

The previous chapter presented a literature review and the theoretical foundations of the research. This chapter introduces the research paradigm and design used to study the experiences of secondary school mathematics teachers' professional development and its impact on their teaching skills in Addis Ababa city. A brief description of the selection of the population, sample, instrumentation, data collection techniques, data analysis procedures, and ethical considerations follows it. The main question of the study was: To what extent does the existing professional development help teachers to be equipped with the skill of creative teaching? The primary issue of this study was empowering mathematics teachers with the skill of innovative teaching through professional development. The selected research methodology and design were found relevant in addressing the following research questions:

1. What are mathematics teachers' perceptions of creative teaching of mathematics?
2. How do the official textbook and suggested teaching materials used in teaching mathematics relate to teachers' and learners' real-life contexts?
3. To what extent do mathematics teachers apply creative teaching practices in their classrooms?
4. What is the role of the existing CPD in equipping mathematics teachers with the skill of creative teaching?

3.1 Research paradigm

A research paradigm is a general organizing framework for theory and research that includes basic assumptions, key issues, models of quality research, and methods for seeking answers (Babaeer, 2021; Leedy, Ormrod & Johnson, 2021). It is a worldview regarding research shared by a community of researchers, encompassing beliefs, assumptions, ideas, biases, and practices that govern the research process. To put it more briefly, it is a method of thinking about and conducting research. This research was grounded in an interpretative research paradigm, which served to guide in investigating how far mathematics teachers' professional development helps teachers acquire creative teaching skills.

The interpretive paradigm, where most qualitative research is grounded, focuses on how individuals attempt to make sense of the world they experience and live in (Babaeer, 2021). According to this worldview, reality is socially constructed. There is not just one observable reality. A single event might have numerous realities or interpretations. Each mathematics teacher's subjective worldview shapes how they teach, behave, and manage their classroom. So, this study intends to recognize secondary school mathematics teachers' perceptions, CPD experiences, and teaching skills. Here, the researcher does not "find" knowledge but constructs it. Constructivism and interpretivism are frequently used interchangeably. Cresswell and Cresswell (2018) explain:

The interpretive paradigm assumes that individuals seek an understanding of the world in which they live and work. Individuals develop subjective meanings of their experiences-meanings directed toward particular objects or things. These meanings are varied and multiple, leading the researcher to look for the complexity of views rather than narrowing meanings into a few categories or ideas...Often, these subjective meanings are negotiated socially and historically. They are not simply imprinted on individuals but formed through interaction with others (hence social constructivism) and historical and cultural norms in individuals' lives. (p. 46)

Mathematics teachers genuinely want to help their learners according to their experience and belief in competence in teaching mathematics. Their perceptions of mathematics are subjective and varied, hence their teaching approaches. It is due to their exposure and experience and can be adjusted since they are formed by interaction with others, not inborn. In addressing these, the interpretive research paradigm is characterized by its specific ontology, epistemology, methodology, axiology, and rhetoric (Johnsen & Christensen, 2019). A teacher's teaching skill is fluid, dynamic, and changing over time and place (ontology). Researchers can understand these subjective experiences by interacting with teachers, as well as personal reasons or motives that shape teachers' internal feelings and guide decisions to act in particular ways (epistemology). The interaction with teachers should be done in the way they feel safe (axiology) and in the language they best understand **(**rhetoric**)**. The most effective method for achieving this is qualitative research (methodology).

3.2 Research design

The study used a qualitative research design from an interpretive paradigm. It assumed a transcendental phenomenology approach by Moustakas (1994), modified from German philosopher Husserl (1931) to capture the essence of mathematics teachers' CPD and teaching experience. This phenomenological study aims to grasp the essence of participants' lived experience of the phenomena and characterise the impact of the existing professional development on mathematics teachers' teaching abilities in depth (Yuksel & Yildirim, 2015).

This design helps to depict the essence of the conscious and lived common experience of secondary school mathematics teachers. According to Creswell (2014), this kind of study looks for the core meaning of the participant's experience (essence), which focuses on the intentionality of consciousness in which experience includes both external appearance and internal consciousness depending on memory, image, and meanings. Therefore, the study intended to explore mathematics teachers' use of creative teaching strategies acquired in the CPD program in teaching their subject. In addition, the associated benefits of CPD are addressed using different data collection techniques such as document analysis, lesson observations, and post-lesson interviews (Throne, 2020).

In this research, the object of the phenomenon is the use of professional development experience for creative teaching in teaching secondary school mathematics. The subject is teachers of mathematics in secondary schools. The act of experience in this study, which is the meaning of the essence, is using CPD for creative teaching. Therefore, the study explored to what extent teachers use the creative teaching skills they obtained during CPD training in teaching mathematics.

3.3 Key Features of Phenomenology

The following critical notions of the phenomenological philosophy will be examined to understand the phenomenological study. Key concepts such as lived experience, intentionality, epochè, phenomenological reduction, imaginative variation, and co-researchers will be introduced to comprehend the framework of phenomenological research.

3.3.1. Lived Experience

Phenomenological research aims to reach the essence of individuals' lived experiences within a defined phenomenon. Phenomenological studies' start and end points are the participants' lived experiences, which should be relevant and essential experiences of the phenomenon (Moustakas, 1994; van Manen, 2016). The concern of this study is to investigate the essence of secondary school mathematics teachers' professional development programs and creative teaching experiences. Therefore, participants demonstrated meaningful experience with CPD and its significance in creative teaching.

3.3.1 Intentionality

The central focus of phenomenology philosophy is on experience and how experiencing something is transformed into consciousness (Yuksel & Yildrim, 2015). Mathematics teachers' intentionality directs their consciousness toward creative teaching. Intention describes the orientation of the mind towards its objects. The concern of this study is to unfold teachers' conscious and deliberate CPD experience towards creative, challenging, and unusual methods of instruction and remove unintentional words and acts that may appear during the interview and observation.

3.3.2 Epochè

Epochè is a Greek term Husserl (1931) used to denote that the researcher should suspend or abstain from preconceived notions, feelings, emotions, or judgments regarding the phenomena under investigation (Leedy, Ormrod & Johnson, 2021). Epochè aids in being objective when describing reality by bracketing out the researcher's experience. So that the researcher's emotions and experiences cannot interfere with the study findings and conclusions (Madondo, 2021), in this research, the researcher suspended his views about professional development for creative teaching and depended on statements provided by the research participants.

3.3.3 Phenomenological Reduction

The objective of phenomenological reduction is to lay out the general characteristics of the phenomenon; components that are not immediately within conscious experience were left out (Yuksel & Yildirim, 2015). This notion was accomplished by removing overlapping, repetitive, and ambiguous statements, i.e., cleaning the raw data. In this research, it was necessary to exclude participant interview responses that did not directly relate to the study's subject.

3.3.4 Imaginative Variation

Imaginative variation is a phenomenological analysis process that follows phenomenological reduction. It relies solely on the imagination of the researcher instead of the empirical evidence (Yuksel & Yildirim, 2015). The objective was to construct structural descriptions of a phenomenon. The underlying and precipitating factors account for what is being experienced. To put it another way, the "how" refers to circumstances that shed light on the "what" of experience (Moustakas, 1994, p 85). This research aims to eliminate extraneous elements by determining the potential meaning of the phenomenon and posing a question concerning the phenomenon (Yuksel & Yildirim, 2015).

Participants may have different, divergent, even contradicting responses towards their experience of professional development and teaching. In such kind of reality, Moustakas (1994) suggests that the researcher must "*…utilize his imagination, varying the frames of reference, employing polarities and reversals' and approaching the phenomenon from divergent perspectives, different positions, roles, or functions…" (p. 85).* This technique is repeated until the common meaning of the phenomenon of interest is discovered (Cresswell & Cresswell, 2018).

3.3.5 Co-researchers

Moustakas (1994) characterized all research participants as co-researchers since the essence of the phenomena is generated from participants' views and experiences, irrespective of the researcher's interpretation. The meaning of the phenomenon is provided by the participants' narratives of their experiences. The researchers' role is to create textural, structural, and textural-structural narratives that do not include their subjectivity (Yuksel & Yildirim, 2015). In other words, transcendental analysis does not need interpretation by researchers. This study considers all six mathematics teachers (research participants) as co-researchers.

3.4 Population and Sampling

3.4.1 Target population

A population is a collection of individuals or circumstances, whether persons, objects, or occasions, which conform to particular conditions and share common characteristics that the researcher can distinguish and study, from which a sample is taken and to which we expect to generalize the findings of the study (Mcmillan & Schumacher, 2014; Creswell, 2012; Leedy, Ormrod & Johnson 2021). The target population for this study was secondary school mathematics teachers and CPD experts in Addis Ababa.

3.4.2 Study site

Qualitative researchers typically gather information in the field, at the location where participants encounter the issue or problem under investigation (Creswell & Creswell, 2018). The site of this study was in Addis Ababa city administration-selected secondary schools. Addis Ababa is the capital city of Ethiopia. In the beginning, the study was planned to be done in South-Eastern Tigray Secondary Schools. Unfortunately, owing to the unforeseen war that erupted on Nov 3, 2020, the site was changed to Addis Ababa. The research was done on purposively selected three secondary schools: one government school, one private school, and one missionary school, mainly because of the school's diversity and location (all are in the researcher's residential sub-city) to collect data closely.

There are four types of secondary schools in the city: government-owned schools (G), mission-owned schools (NGO), private schools (P), and international community schools (ICS). The study does not include the community schools; the researcher believes they cannot represent schooling in Ethiopia, as most of their learners are foreigners and have curriculum differences.

For example, the International Community School (ICS) in Addis Ababa uses the American curriculum model, and its learners are from different nations. The researcher wants to see professional development experience in these three diversified schools. The schools are named $G(government), P(private), and\ N(NGO)$ for this study.

School G:

School G is a government-owned secondary school located in the Akaki Kality sub-city. The school was founded in 2001 with learners from grades 9-12. The school has a total enrollment of 2,318 learners (learn in 41 sections) and 80 teachers; 13 are mathematics teachers as of 2022. Out of them, three are MSc holders, and the others are with BSc. Only one mathematics teacher is female; this reflects the perception that mathematics is not for females but for males. In the Ethiopian context, most females study fields with few calculations, such as social sciences. Each classroom has a plasma T.V. broadcast beaming from South Africa. There are two ICT labs with about 57 functional computers and one science laboratory. This school is fee-free, like all government schools in Ethiopia.

School P:

School P is a privately owned school established in 1998 G.C (1991 Ethiopian calendar) in Akaki Kality sub-city. The school serves KG-12 grades with about 4000 learners and 250 staff members. There are 1,035 learners and 43 teachers in secondary school (9-12). From these, five staff members teach mathematics in this secondary school. There are a total of 24 sections in the secondary school. All the mathematics teachers are male; for the above reason, females do not want to join the mathematics department. Among them, four are BSc holders, and one is an MSc holder. The school has three labs for biology, chemistry, and physics.

There are 25 functional computers in the ICT classroom. This school does not have a plasma television but an LCD and the usual television for teaching purposes. It is among the expensive feepaying schools in Addis Ababa. This school was selected because of its location and the vast teaching experience from the Akaki Kality sub-city private schools.

School N:

School N is an NGO school established in 1980. The school has learners from grades KG-12, but the concern of this study is in secondary school. There are 16 teachers and 477 learners enrolled in this secondary school. The school's enrolment was even lower than this number because of the lack of roads (its location could be classified as remote compared to other schools in the sub-city and Addis Ababa), which means there was no transportation. Currently, a road passes through the school, and there is an improvement in the number of learners. There are three secondary school mathematics teachers, and all are male. The learners learn in eight sections, and the ICT room has 13 computers. The school charges fees but is affordable for parents; it has one science lab, and no plasma television is present. The school is also a boarding school for orphan learners.

3.4.3 Sample and sampling techniques

A sample is a representative part of the target population that the researcher intends to study and generalize the result about the target population (Creswell, 2012; Mcmillan & Schumacher, 2014). The researcher chose purposive sampling (Johnson & Christensen, 2019; McMillan & Schumacher, 2014) in selecting the research participants' schools and teachers. Purposive sampling is a non-probability sampling technique used to identify the main participants (HR & Aithal, 2022) because it demonstrates some features of the researcher's interest (Silverman, 2013). According to Creswell and Creswell (2018), purposive sampling techniques are used by qualitative researchers to search for participants who can best aid them in understanding the phenomenon under investigation. The study concerns the professional development experience and its impact on creative teaching. Hence, the study must include senior schools and teachers since they have rich experience in CPD and teaching.

In purposive sampling, participants are selected using defined characteristics. A sample of participants was chosen according to the purpose of the study, looking for individuals who have had first-hand experiences relating to the phenomenon of professional development (Johnson & Christensen, 2019). In this research, the criteria were teachers with five years and above experience in teaching in the selected schools, and CPD experts with similar experience with teachers were also selected. The selected sample for this study was two professional development experts and six mathematics teachers from three Addis Ababa secondary schools.

Thus, six teachers and two professional development experts from Strengthening Mathematics and Science Education in Ethiopia (SMASEE) participated in this research.

Unfortunately, the CPD experts in SMASEE did not have experience in secondary schools. They train elementary school teachers by naming mathematics as 'book 2'. Therefore, the data gathered from the CPD experts were not included in the research data. Teachers from the government school have code names represented as G1 & G2; for private schools, P1 & P2; and for the NGO school as N1&N2.

Table 3. 1: Sample teachers with qualifications and experience

No	Teacher	Sex	Qualification	Experience in teaching mathematics
1	G1	Male	B.Sc.	12years
2	G2	Male	B.Ed. +M.Sc.	28years
3	P1	Male	B.Sc.+M.Sc.	11years
4	P2	Male	B.Ed.	13years
5	N1	Male	B.Ed.	13years
6	N2	Male	B.Sc.	7years

3.5 Research instruments

This section describes the instruments employed to collect information. The data-gathering instruments employed in this research were document analysis, observations, one-on-one interviews, and telephone interviews in three Addis Ababa secondary schools. Furthermore, the researcher functions as a data collection instrument because the bulk of the data collection relies on the researcher's participation in the setting (Leedy, Ormrod & Johnson, 2021). Wood's features of creative teaching and Cremin's dimension of creative teaching informed all the instruments.

3.5.1 Document analysis schedule

Document analysis comprises investigating the contents of documented materials such as books, publications, magazines, audio-visual, photos, and all other oral resources, which could be either verbal or printed and contain information obtained from the past or present (Madondo, 2021). Documents helped to identify the previous trends of professional development, the experience of indigenous mathematics knowledge, and the teaching and supporting material's contribution to teaching mathematics creatively.

School official documents, including the national syllabi, lesson plan, textbook, CPD toolkit, and CPD framework programs, were analysed for their inclusion of the phenomenon under study. These resources offer insightful data that researchers can utilise to comprehend key phenomena in qualitative research. Document analysis was conducted to obtain background information and to ascertain whether implementing mathematics teachers' professional development for creative teaching reflects program plans as previously stated in the school's official documents. This section contains how far the documents address Wood's four features of creative teaching.

Table 3. 2: Document analysis sample

1. Lesson objectives consider connection-making between school mathematics and real-life experience.
2. Syllabus materials are helpful toward teacher autonomy.
3. The lesson plan starts a new topic by asking questions.
4. The syllabus provides a diversity of teaching aids.

3.5.2 Interview guide

Semi-structured interviews were the second data collection instrument employed in this research. This instrument consists of open-ended questions. This instrument helps the researcher maintain the interviewee's focus, ask questions flexibly, and ask the participants to answer the interview questions openly. The semi-structured interviews were vital as they were more open, dialogic, and conversational (Buys, Casteleijn, Heyns, & Untiedt, 2022) concerning mathematics teachers' professional development and teaching experience.

The interview guide has two parts: the one-on-one interview and the telephone interview. The first part was focused on one-on-one interviews. The one-on-one interview addressed every participant's experience, ideas, feelings, perceptions, and recommendations toward professional development for creative teaching. This instrument gives equal chances for every participant and helps to get sensitive issues those participants may fear raising, for example, in a group interview. This one-on-one interview guide has two sections. Section A concerns the teachers' teaching experience. For instance, "When did you start teaching secondary school mathematics?" "How do you see the teaching profession?" These introductory questions created a relaxed and focused environment whereby research participants could express themselves freely. Teachers' perception and practice of creative teaching and the relevance of the textbook were addressed. Wood's features of creative teaching informed this instrument.

The questions in this section include the ones below as examples.

1. What is creative teaching to you?
2. Why do you think learners fear and fail in mathematics more than other subjects?

Section B deals with the teacher's view on the importance, practicability, and recommendations of a professional development program they took towards their classroom teaching. How could the continuous professional program help minimize the gap between textbook knowledge and indigenous knowledge of mathematics or out-of-school mathematics experience?

1. How do you see the practicability of the CPD you took in teaching mathematics?
2. Would you describe what you think the ideal CPD program for creative teaching should be?

Interviews provided access to a significant amount of data. In contrast to other instruments, such as questionnaires, one question or response led to another (Creswell, 2014). For instance, questions such as: Do you try to connect between school and real-world mathematics in teaching your learners? If their answer was yes, they were asked to give an example. If their answer to the above question was no, the interviewees were asked to state their reason. The last phase of the interview question was about participants' recommendations. For example, how do you recommend enhancing professional development for creative teaching? What else would you like to share about your experience of professional development? The interview came to an end with the help of this concluding question. A quiet place within the school compound was selected, and all interviews conducted with the six teachers were audio recorded and transcribed.

The second part was a telephone interview. In compiling the chapters, further information was needed; hence, the researcher transcribed the participants' telephone numbers in their corresponding interview transcription papers. The telephone interview helps to be more confident in making clear ambiguous data during the interview and in including missed information and further clarification. The telephone interview provides the best information source whenever the researcher cannot access individuals directly (Leedy, Ormrod & Johnson, 2021) and wants to make clear ambiguous ideas.

The questions asked in the telephone interview include:
Who owns the CPD that you took in your school?

From a teacher interview, the researcher learns that the mathematics department is considered a CPD team and meets every two weeks. Another interviewee informs the researcher that the CPD has no owner; some trainers come from city administration, others from sub-city and districts with different agendas. So, further clarification was necessary to grasp the essence of these two ideas.

3.5.3 Observation

All that is written and the teachers said may not practise; what the teachers do is what is going on in their teaching practice; hence, observation was the following instrument. The purpose of this instrument was to gather information on three teachers' instruction methods, one from each school, the physical environment of the classroom, and interaction among and between teachers and learners to explain the potential methods of instruction that can improve their skills for creative teaching of mathematics. The observation guide was informed by Cremins' creative teaching dimensions and Woods' innovative teaching features. Following the observation, a detailed observational matrix was created from the field notes (as shown in Table 3.6 below) (Throne, 2021). The lesson observation schedule was divided into three dimensions (Cremin, 2009), with four features of creative teaching each (Woods, 1990). Part I focused on the teacher's personal qualities in teaching mathematics creatively; the following characteristics were observed;

Table 3. 3: Observation Sample I

1. The teacher uses his imagination to make a connection.
2. The teacher is responsive to the learner's ideas and situations.

The second part (part II) was about the pedagogical practice of mathematics teachers. The following features were observed:

Table 3. 4: Observation Sample II

1. The teacher connects school mathematics and the learner's experience of mathematics.
2. Does the teacher start the lesson by asking questions?

The last part, part III, was about the classroom ethos and the learner's emotional comfort. The following characteristics were observed:

Table 3. 5: Observation Sample III

1. The teacher provides enough time for the learners to struggle.
2. The teacher respects the learner's unusual ideas.

This instrument serves as a foundation for the post-lesson one-on-one interview.

Table 3. 6: Summary of the lesson observation matrix

		Dimensions of creative teaching		
		Personal quality	***Pedagogy***	***Classroom ethos***
features of creative teaching	***Relevance***			
	Control			
	Ownership			
	Innovation			

3.5.4 Pilot testing of research instruments

A pilot study is a minor future study meant to redefine methodology. According to Creswell and Creswell (2018), "… *the initial research plan cannot be tightly prescribed, and some or all phases of the process may change or shift after the researcher enters the field and begins to collect data. For example, the questions may change, the data collection forms may shift, and the individuals studied, and the sites visited may be modified"* (p. 258).

Therefore, the pilot testing was to test the instrument's validity before use (Creswell & Creswell, 2018). A pilot study is required to find measurement procedure defects and identify unclear or ambiguous elements in an instrument. A pilot study was conducted on one government secondary school for the interview and observation tools. The researcher obtained an assistance letter from the Addis Ababa city administration education bureau to collect data in two government secondary schools. One of the schools was used for the pilot test.

The first one that the pilot test informs the researcher is the sequence of instruments. The researcher considers conducting an interview, observation and then documenting analysis, respectively. Later, the researcher understood that to obtain relevant data, documents needed to be analysed first. The researcher should know the documents the teachers use to teach and the CPD materials. Following this, one-on-one interviews need to be conducted. After that, the researcher needs to compare what was said during the interview and planned in the lesson plan and which part was changed into classroom practice. Finally, post-lesson observation interviews need to be followed.

The second one was an observation tool. In the beginning, the researcher observed using blank paper to record the observed behaviour, but that information was imprecise. Later, the observation matrix was prepared in line with Woods' features of creative teaching in terms of Cremin's dimension of creative practice, as seen in Table 3.6, which makes the observation focused.

The third one is from the interviewee's response; the researcher observes that some overlapping questions must be merged systematically. The pilot test result also indicates that Wood's creative teaching features and Cremin's creative teaching dimensions used as a theoretical framework should strictly inform the interview instruments; otherwise, the instruments would be vague. The questions: *What techniques do you use to teach mathematical tasks/concepts which are difficult for learners? Do you show your learners' techniques for tackling a problem that is not described in the text?* After the pilot test, they were merged to: *To what extent do you go beyond what is written in the textbook you teach to provide relevant tasks, especially when learners struggle to understand?*

3.6 Ethical considerations

Research that involves humans must respect the rights of the participants. The steps that the researcher follows to get access to the study site and participants and the measures taken to keep the confidentiality of the information that the researcher obtains from participants are presented in the following subsections.

3.6.1 Gaining access

In research involving human participants, the researcher's most important and fundamental ethical issue is handling research participants (Johnson & Christensen, 2019). It is a requirement to know the ethical and legal accountabilities of doing research. Therefore, ethics must be followed in all research endeavours. Respecting the rights of study participants is a key component of ethics. The Addis Ababa City Administration Education Bureau and the UNISA

Ethics Committee approved the study's conduct, which was conducted with their permission. The following section discusses further ethical issues taken into account

3.6.2 Gaining permission

This research adopted a transcendental qualitative approach, establishing direct personal contact with the participants. The process of gaining access to the study sites began with a visit to the Addis Ababa city administration education bureau with an ethics certificate from the UNISA College of Education (see Appendix D) and a letter from the UNISA Ethiopia centre directed to the Addis Ababa education bureau seeking permission to research in Addis Ababa secondary schools (see Appendix E). After receiving authorisation from the Addis Ababa Education Bureau, the researcher visited each of the three schools.

The three school principals and the leaders of their mathematics departments were briefed on the purpose of the study, and then approval was granted to proceed. The department heads introduced the researcher to the mathematics teachers, who also informed them of the purpose of the visit. The potential relevance of the study was briefed to the participant teachers at the initial contact. This warm reception was crucial in helping the researcher earn the respect and cooperation he needed to continue working with the schools. Two teachers per school were selected to participate in the study.

3.6.3 Informed consent

The goal of the study was expressed to the participants. An overview of the research project was given to the participants. The informed consent document communicated to the prospective research participants the researcher's name, the study's goal, sponsors, and procedures, including the time commitment of the subject, the privacy of their information, and the researcher's contact details (Madondo, 2021). Research participants signed the informed consent form before lesson observation and interview. Participation was voluntary, and the participants were assured that they could terminate their participation in the study at any time without harm or danger.

3.6.4 Confidentiality

According to Taquette and Borges (2022), confidentiality means that recognizable information collected about participants' privacy issues during data collection will not be revealed. Additionally, the identity of research participants will be secured through several processes designed to secure them, except they specifically need to be identified. That is, treating the information regarding the respondents' identities secretly. Participants were guaranteed that their identity and their secondary schools' names would be kept confidential before data gathering (Creswell & Creswell, 2018). Hence, the names of the schools were referred to as G, P, and N. The participants were informed that their identity would not be revealed to anyone, and their interview was recorded using a code name. They were also informed about what would be done with the data they gained; it would be only used for research.

In maintaining their comments' anonymity and safeguarding them from retaliation, the participant's privacy and confidentiality were upheld by not requiring them to divulge their identities. The respondents were asked up front if they had any concerns about taking part in the study or if they anticipated any harmful effects from doing so to reduce any harm that might have been done to them. The participating teachers at the schools offered their verbal consent and assisted in organising the meeting with them. In the teachers' consent form, the participant's right to anonymity was guaranteed, and no real names were used in this study or any other publications written regarding the study's results (Madondo, 2021).

3.7 Data collection procedures

This phenomenological study involved three secondary schools where detailed explanations of the phenomena under study were gathered through observations, interviews, and document analysis as data collection methods. Collecting data depended on careful timekeeping, constant planning, and re-planning until saturation (Pope & Mays, 2020). The researcher developed a tentative schedule of meetings with the involved schools (See Appendix F).

The first data collection phase involved an assessment of the official school documents used to teach and support staff development for creative teaching. Attention was needed to focus on how much they support teaching mathematics creatively (See Appendix G). Four documents were available for analysis, including lesson plans, syllabi, mathematics textbooks, and CPD materials prepared nationally.

Phenomenological interviews were used in the second phase of data collection. Throughout this phase, data were gathered through a one-on-one interview with the six mathematics teachers. The main goal was to explore teacher perceptions, exposure, experiences, and attitudes toward CPD in creativity and creative mathematics teaching. The interview was conducted based on the prepared open-ended and closed questions **(**see Appendix H).

Most of the interview was directed by a list of questions that were few (about six**)** to be discovered from the response of study participants **(**see Appendix H(b)**)**. The precise wording and the sequence of the questions were fixed ahead of time. This arrangement enables the researcher to respond appropriately to the emerging worldview of the participant and new concepts in the title (Merriam & Grenier, 2019). A quiet place was determined to avoid disturbance; the interview was audio recorded and transcribed. The recorded and transcribed data were stored in a safe place after the data were gathered for analysis.

To motivate teachers to participate, the researcher introduced snacks, biscuits, 'qollo' (roasted grain food), tea, coffee, and soft beverages before and after the interviews. The interviews were incredibly laid-back and focused. According to Frazer and Lawley (2000), the researcher must take all steps possible to promote a better response.

In the third stage of data gathering, two classes from each school were used to observe teaching and learning activities. This phase examined teachers' teaching skills, the classroom's physical environment, and interaction among learners and between learners and teachers (See Appendix I). Teachers were observed during their regular teaching schedule to gather direct observational data and better illustrate the overall experience of teaching mathematics. The researcher was a non-participant observer. The researcher's role was to listen, observe, and record information without participating in mathematics lessons under observation (Kellehear, 2020).

Following all these, a telephone interview was conducted to get missed information. These were the techniques used by the researcher to get data. The data collection process, as in the figure below, starts by locating sites, gaining access, selecting participants based on criteria, collecting data, recording information, resolving field issues, and ends by storing data.

Figure 3. 1: Data collection activities adapted from Creswell (2013)

3.8 Phenomenological Data Analysis

Here, the researcher needs to make sense of the collected data by filtering and interpreting them (Pope & Mays, 2020). This study used qualitative methods for data analysis. The qualitative data analysis process involved categorizing data and identifying relationships (McMillan & Schumacher, 2014) regarding Wood's four features of creative teaching and Cremin's three dimensions of creative teaching. As a result, when analysing the data, the researcher searches for themes, patterns, consistency, and exceptions. A more detailed approach employed is elaborated on below. The data analysis follows Moustakas' phenomenological data analysis procedure.

The phenomenological analysis begins by bracketing the researcher's subjectivity and clarifying preconceptions throughout the research. This process is called epoché; it denotes setting away the researcher's preconceptions and biases about the phenomenon. The researcher's experience with the object of study was described to detect subjective judgments and preconceptions; hence, they do not affect the analysis process. The overall steps followed are described in the figure below.

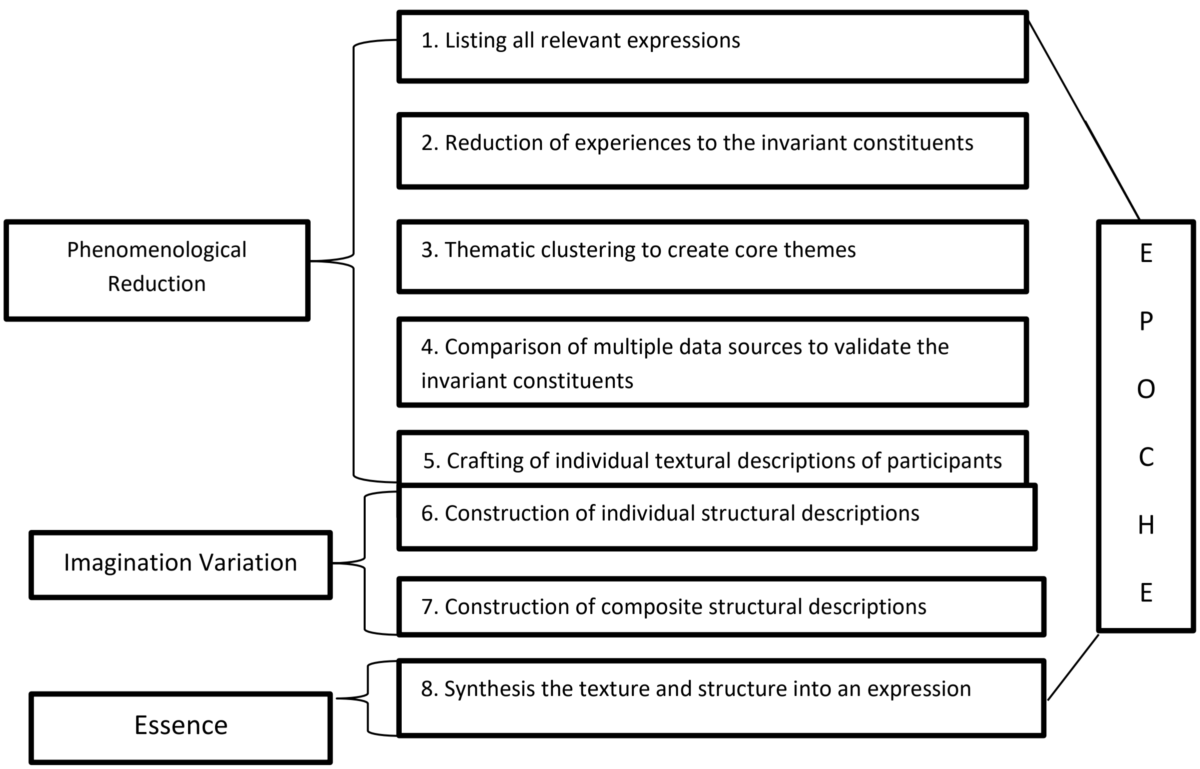


Figure 3. 2: Steps of data analysis Adapted from Yuksel and Yildrim (2015)

The data analysis steps

1. **Horizontalizing:** After collecting the necessary data for the research, the researcher reads all the collected data to identify and classify relevant and irrelevant information. All irrelevant, overlapping, and repetitive statements concerning the phenomena were

removed. After removing irrelevances from the data, the remaining portion of the data is known as *horizons* (Yuksel &Yildrim, 2015). These horizons are the textural meanings or basic elements of the phenomenon. According to Moustakas (1994), horizons are limitless, and horizonalisation is a never-ending process.

2. **Reduction of experiences to the invariant constituents:** During this stage, the researcher classified horizons into meaning themes. These themes have only a single meaning. This phenomenological reduction stage describes the phenomena using "*textural language*."

3. **Thematic clustering to create core themes:** The researcher then clusters and thematizes the invariant constituents, i.e., the horizons recognised as the phenomenon's "core themes of the experience" (Moustakas, 1994, p. 121).

4. **Comparison of multiple data sources to validate the invariant constituents:** The researcher compares the themes generated from the experience of co-researchers using one data gathering method, say one-on-one interview, to other data collection methods like document analysis, observation, one-on-one interviews, and telephone interviews, to authenticate accuracy and clear representation throughout the data sources.

5. **Constructing individual textural descriptions of participants**

The textural description is a narrative that explains co-researchers perceptions about a phenomenon. At this stage, the co-researchers' experiences were described using their exact wording. Moreover, the meaning of units in a narrative format was explained to facilitate the reader's comprehension of the research participants' experiences.

6. **Construction of individual structural descriptions:** the researcher uses an imaginative variation to create structures depending on the textural descriptions described above by imagining and analyzing how the experiences in the textural description occur.

7. **Construction of composite structural descriptions:** Following writing the textural explanation for every co-researcher, the researcher incorporates the textural into a structure explaining how the experience occurred by adding the structures after each paragraph to generate a structural description. Understanding the co-researchers' experiences with the phenomenon under investigation is aided by this procedure.

8. **Synthesizing the texture and structure into an expression:** For every co-researcher, two narratives were created, one textural and one structural, outlining "what" and "how" it happened, respectively. Next, a list of each co-researcher-meaning unit was presented. Following that, meaning units shared by all co-researchers were established, and these shared meaning units served as the foundation for composite textural and structural descriptions. Individual meaning units were removed to generate the phenomenon's essence in the composite textural and structural descriptions. The researcher wrote composite narratives from the third-person perspective representing the group. This step synthesizes all narratives for the group as a whole. The composite structural and textural descriptions are integrated to describe the phenomenon under research comprehensively. The purpose of the step is to reach the essence of the experience of the phenomenon (Yuksel &Yildrim, 2015).

The qualitative data analysis used Wood's creative teaching features and Cremin's creative teaching dimensions as the theoretical framework, as shown in the table below. In presenting qualitative data, a thick description helps provide different perspectives about a theme from different data sources to interconnect the findings. For example, with the data collected from observation of teachers under the feature relevance and its dimension shown in the table below, an investigation was made to explain whether or not lessons were relevantly introduced. Was it usual, or was it creative for the learners? To what extent did it motivate the learners to become more and more engaged in the learning process, as shown by their participation and attentiveness?

Table 3. 7: Data analysis guide

		Dimensions of creative teaching		
		personal characteristics	***pedagogical practices***	***classroom ethos***
Features of creative teaching	***Ownership***	Do teachers have secure Subject matter knowledge	Whether teachers are transmitters of others' knowledge or owners of creative knowledge	Do teachers Share the responsibility of teaching and learning with learners?
	Relevance	Teachers' knowledge of learners' background	Weather teachers make a connection between school and real-life mathematics.	Was the classroom interactive and safe to make mistakes?
	Control	Teacher's Responsiveness to leaners Ideas	If/whether teachers start the lesson by asking questions	Do teachers provide enough time for learners to struggle with problems?
	Innovation	Do teachers have an awareness of being creative?	Do teachers apply flexibility in teaching styles?	How do teachers Value learners' unusual ideas?

The features and dimensions in Table 3.7 served as an important guide for the lessons observed. They were used to analyze whether teaching mathematics emphasized, for example, the connection-making between school and real-life mathematics and other subjects and within chapters and topics of the subject. This section focuses on the teacher's use of their imagination to connect school and out-of-school learners' experience of mathematics with other subjects and within the subject, as mathematics is a connected subject.

The matrix table helped to evaluate the teachers' teaching since it covers key features and dimensions of mathematics lessons. For example, the feature control and classroom ethos dimension described how collaborative instruction techniques were used to engage learners in justifying, supporting, defending, and challenging mathematical ideas. In addition, each document analysis was coded depending on the particular features concerning their dimensions. Every feature was coded by judging the extent to which the syllabus and lesson plan used for teaching activity adhered to the requirements of the features of creative teaching. The coding scheme used in this instance is as follows: 'No' - (1); 'Partially' - (2); and 'Yes' - (3). For example, if the lesson plan encourages teacher-centred instruction method on feature (control), the code (1) - 'No' was chosen to indicate that the learners were not participating.

The degree of conformity with, or deviation from, the Woods features of creative teaching and Cremin's dimension of the creative practice of the learning phases, as seen in the checklist table 3.7 above, illustrates how to measure the teaching opportunities presented by the teachers. Overall, the technique consisted of converting lesson observations into information-produced data that showed how closely observed teaching methods matched Woods's features of creative teaching.

In this study, the matrix table 3.7 played a significant role in understanding most empirical data. It was best achieved through inductive analysis, moving from a specific to a general understanding of the phenomena. Several viewpoints of respondents were noted, allowing the frequent, dominant, or significant themes inherent in the raw data to emerge.

3.9 Validity considerations

The validity of qualitative research refers to the trustworthiness of the data interpretation. The following four accountability standards answered the trustworthiness of the study: credibility, dependability, transferability, and conformability, and therefore, it is defensible. Trustworthiness is a term used to describe the rigour or rigidity in a study that results from the validity of the research methodology and the use of triangulation to gather data (Adler, 2022).

Data sources triangulation shows using several information sources in a single study for authentication purposes (Stahl & King, 2020). Cilesiz (2006) indicated that "*Collecting data from two sources from the same participants enables the researcher to compare the information from both data sources and to eliminate any inconsistencies, which would indicate untruthful data*" (p. 60). It is all about cross-checking among data sources and data collection strategies. The researcher uses observation, one-on-one semi-structured interviews, telephone interviews, and document analysis as data sources for triangulation. Combining these three instruments helps to confirm the trustworthy outputs of the research.

3.9.1 Credibility: Credibility tells us if the research design and method are appropriate for the research questions. Research outcomes must represent believable information from the respondents' original data and accurately interpret the participants' original views. This accountability feature was ensured through data triangulation (Creswell & Creswell, 2018), where more than one data collection method was used. "The results from each (data collection) method converge and indicate the same result, (hence) there is triangulation and thus greater credibility in the findings" (MacMillan & Schumacher, 2014, p.34).

For triangulation, multiple sources of data were used in this research (Kornuta & Garmaine, 2021). Some participants were interviewed and observed their lessons. Then, look for common themes in the data gathered from both instruments (Leedy, Ormrod & Johnson, 2021). Thus, Lesson observation helped cross-check the teacher's response during the interview. For example, teachers say they provide the course by connecting school mathematics to the learners' out-of-school experience, but the researcher did not find this during the observation. Therefore, the researcher drew common themes from multiple data sources.

3.9.2 Dependability is about consistency if it enables one to repeat a study using overlapping methods and in-depth methodological descriptions of the procedures (Leedy, Ormrod & Johnson, 2021). To enhance the study's dependability, the researcher used member checks as a strategy

(Kornuta & Germaine, 2019). In this process, the researcher asks the participants about their interview transcription horizons to verify the researcher's understanding. For example, when an interviewee's response included aspects other than those to do with professional development for creative teaching, data cleaning was done and showed respondents the horizons for verification.

3.9.3 Transferability: It is about the research to what extent the outcome can be transferred to different contexts or settings and participants. The researcher gave detailed information regarding the participants' backgrounds and study locations. The study was also conducted in a natural setting, and a criterion-based representative sample was selected; this helps to draw the contexts where the research findings can be generalized (Yuksel & Yildirim. 2015) and makes it easier for readers to understand how the data was interpreted.

3.9.4 Confirmability: Regarding the instrument validation, the theoretical framework, Wood's features of creative teaching, and Cremin's dimensions of creative teaching were used to inform instrumentation. It included ownership, relevance, control, and innovation regarding personal quality, pedagogy, and classroom ethos. These features in terms of the dimensions were the focus of this study; the document analysis, interview guide, and observation guide were prepared in accordance with the theoretical framework. As a result, the construct validity was guaranteed because the instrument measured what it was intended to measure (Creswell, 2012).

3.10 Chapter Summary

The focus of the chapter was to describe the research methodology and design used to gather and analyze the collected data. The researcher uses an interpretative research paradigm suitable for a qualitative approach. From the qualitative method, transcendental phenomenology was adopted as a research design. The chapter explains the research methods, the research site and participants, the data collection and analysis, ethical considerations, and validity issues were discussed.

The discussion showed how the research participants were chosen based on a purposive criterion-based sampling method. The instrumentation, procedures used in data collection, ethical issues, and the steps employed for data analysis to address the main research question that guided the research were presented. The next chapter presents data analyses and discussions.

Chapter 4: Data presentation analysis and discussion

4.0 Introduction

The main objective of this qualitative data analysis, presented in this chapter, was to provide evidence of teachers' experience of teaching mathematics, professional development, and its impact in equipping them with the skill of creative teaching. In investigating teachers' experiences, the researcher used semi-structured interviews, lesson observation, and document analysis to collect data. Moustakas (1994) provides a variety of approaches and viewpoints for studying an experience to understand the phenomenon being investigated. This study used the transcendental phenomenological design following that advice.

Transcriptions were made of the information obtained through the audio recordings of the interviews and the field notes from the class observations. Six mathematics teachers were interviewed to learn more about their professional development experiences and how these experiences shaped their teaching practice. This study included three schools: government (G), private (P), and non-governmental organisation (N). The six teachers interviewed were named Teacher G1 and Teacher G2 for government school teachers, Teacher P1 and Teacher P2 for private school teachers, and Teacher N1 and Teacher N2 for NGO school teachers. Lesson observation was conducted in these selected three schools. Based on the theoretical framework (Wood's features of creative teaching and Cremin's dimensions of creative teaching), four research questions were developed to guide the study.

Qualitative data was collected using multiple instruments (Madondo, 2021) and was presented and analysed to address the following research questions:

1. What are mathematics teachers' perceptions of creative teaching of mathematics?
2. How do the official textbooks and suggested teaching materials used in teaching mathematics relate to teachers' and learners' real-life contexts?
3. To what extent do mathematics teachers apply creative teaching practices in their classrooms?

4. What is the role of the existing CPD in equipping mathematics teachers with the skill of creative teaching?

This chapter is divided into four sections. The first section presents teachers' perceptions of creative teaching in terms of Wood's four features of creative teaching. The data were collected through semi-structured one-on-one interviews. The relevance of the textbooks was presented in section two using document analysis and semi-structured interviews. The third section was about the teachers' teaching practices; to see what is happening in the classroom, observation, document analysis, and interview were used as means of data collection. The last section was about teachers' professional development experience and its role in enhancing creative teaching; data were collected through one-on-one interviews and document analysis. The results obtained from the three instruments (interview, document analysis, and lesson observation) on each research question are presented, analysed, and discussed below. Each research question was concluded with a summary. Finally, the chapter comes to an end with a chapter summary.

4.1 Research Question 1

What are mathematics teachers' perceptions of creative teaching of mathematics?

The section unpacks the mathematics teachers' perceptions and practices of creative teaching. Data were gathered to answer research question one through semi-structured interviews with six mathematics teachers. Here, an interview was employed to collect data concerning the perception and practice of mathematics teachers. The interview data was presented, analysed, and discussed under the following subthemes: Relevance, control, ownership, and innovation.

4.1.1 Relevance

The concern of this theme was to explore the experience and perception of secondary school mathematics teachers in making mathematics relevant to themselves and their learners. Concerning the relevance of teaching, concepts related to teachers' experience of connection-making are presented. Teachers were asked to clarify how they make connections among chapters, subjects, and out-of-school mathematics or indigenous mathematics knowledge was presented. The interview results are presented below.

Researcher: How do you help your learners in connection-making between school and real-world mathematics?

Teacher G1: *The textbook is not inviting me to do so.*

Teacher G2: *In the chapter probability and statistics …. I use a coin practically to teach my students about probability and also take three or four learners and ask them to play ''Shikut'' game before they work problems on dice and other complex tasks, and I found it better.*

Teacher P1: *In statistics, there are subtopics in percentile, quartile, and decile. The learners did their percentile, decile, and quartile results and identified their location.*

Teacher P2: *Some learners struggle to add fractions like 1/4+1/2; they solve it as 2/6 by directly adding nominator with nominator and denominator with denominator. I asked them if they bought tea for 25 cents and bread for 50 cents and how many cents in total they spent. They do it quickly.*

Teacher N1: *Their life activity in their home, for example, the shape of food they eat and what shapes they see in their surroundings, helps teach fractions and geometry.*

Teacher N2: *Connecting to learners' day-to-day activities, e.g., buying and selling things.*

Table 4. 1: Summary of Teacher's Response to Connection-making

Teacher	*School*	*Real-life experience*
G1	*Government*	*No*
G2	*Government*	*Probability 'Shikut'*
P1	*Private*	*Statistics*
P2	*Private*	*Fractions*

N1	*NGO*	*Fractions and Geometry*
N2	*NGO*	*Buying and selling*

From the teachers' responses presented above in Table 4.1, most of them try to connect the course they teach to their learners' real lives. Teachers G1 and G2 were from the government school. The school teachers have only 25 minutes to teach out of 45 minutes. They introduced the lesson for about 10 minutes, then the plasma TV lectures for 20 minutes, and the teachers concluded the lesson for 15 minutes. Teacher G2 uses the traditional game to connect school mathematics to learners' lives.

Meanwhile, teacher G1 blames the textbook as unhelpful in connection-making; hence, he teaches what is written in the textbook. In the researcher's opinion, blaming the textbook in the 21st century ICT revolution era is meaningless. There are many resources that are helpful in teaching mathematics; teachers could search for relevant examples and exercises on the web and adjust them in a way that helps learners understand the topic under investigation.

From the demographic data in Table 3.1 in the previous chapter, teacher G2 holds a master's of Science in mathematics and a bachelor of education in mathematics. Teacher G2 took courses such as general teaching methods (Pedagogy), curriculum studies, subject methods, special needs Education, educational organization and Management, educational measurement and Evaluation, and educational psychology courses in his undergraduate studies. Therefore, teacher G2 knows how knowledge is constructed by connecting the textbook concepts to the learners' authentic lives. In comparison, teacher G1, who studies applied mathematics, is most concerned with effectively transferring what is written in the textbook. Teaching methods (pedagogy) empower teachers to help their learners' independent thinking and creativity (Mirzaxolmatovna, Ibrokhimovich & Ne'matovna, 2022), which is the requirement of teaching in the third millennium.

The private school is more resourced than the other two schools. It has projectors and televisions for teaching purposes, and the learner’s parents can afford the expenses for teaching aid materials. Teachers P1 and P2 are from this school. Teacher P1 makes a connection to the statistics portion of the text. The teacher found connecting the statistics chapter to learners’ real-life helpful. Here, learners are asked to find the whereabouts of their classroom exam results based on these statistics results. Teacher P2 connects school mathematics to learners' lives by adding fractions using coins (cents). Buying bread and tea is frequently done by learners almost every morning. Here, teacher P2’s explanation was more planned to connect mathematics to the lives of learners than teacher P1’s because teacher P1’s explanation is still within the classroom.

School N is an NGO school that is less resourced in empowering teachers and learners’ competency compared to the other two schools. Teacher N1 connects to the geometry part of the subject he teaches. The teacher tells learners to observe the shape of the food prepared at home and the wheels of cars, windows, and buildings constructed in their surroundings. Teacher N2 uses learners’ day-to-day activities but fails to describe which activities. Hence, Teacher N2 considers it theoretically but not practicable, which is a little different from teacher G1.

From the above discussion, teachers with educational backgrounds try their best to identify and connect school mathematics to the lives of their learners. The researcher’s understanding from the interview is that teachers want to help their learners by connecting mathematics to their lives. Such teachers' desires need to be supported by providing relevant training. Therefore, for teachers to be effective in making mathematics relevant to learners, they need extensive training in methods of teaching or pedagogy, especially connection-making.

4.1.2 Control

In this section, participant teachers respond concerning their teaching styles: whether teachers provide open mathematical tasks to their learners, how they help collaboration among learners in solving problems and responsiveness to learners' interests and concerns.

Researcher: How often do you design open-ended mathematical tasks to encourage your learners to develop different brain paths?

Teacher G1: *I did not ask learners open-ended questions yet*

Teacher G2: *There is a time constraint to ask learners open-ended tasks, and the textbook does not support doing so; it is staffed with predetermined questions.*

Teacher P1*: The word problems in the textbook are open-ended questions; learners come up with the same answer but can follow different methods.*

Teacher P2: *No,*

Teacher N1: *Not from myself, but some tasks in the textbook are open-ended, especially word problems.*

Teacher N2*: No, I did not design*

Table 4. 2: Summary of teacher's response on opening closed problems

Teacher	*School*	*Open problems*
G1	*Government*	*No*
G2	*Government*	*No*
P1	*Private*	*Word problems*
P2	*Private*	*No*
N1	*NGO*	*Word problems*
N2	*NGO*	*No*

From the above table, all teachers do not help their learners by opening closed problems in the text. Teacher G2 justifies that the textbook is full of predetermined tasks; there is only one correct answer for these questions. In addition, the time limit is the other constraint to using open-ended questions, according to teacher G2, as teachers rash to introduce and summarize the lesson within the prescribed period, which is 25 minutes. When we see teacher P1's and N1's responses, the world problems in the text can be considered open questions. Both teachers and learners can follow different paths, even if the last answer is identical. Open problems help learners use different approaches and come up with different correct answers (Suherman & Vidakovich, 2022). This trend leads to cultivating and appreciating mathematical creativity.

In the researcher's opinion, opening up closed problems is not difficult. The textbook may not provide this kind of question, but as every problem can be opened up, it needs commitment on the side of teachers. For instance, the textbook asks to solve the quadratic equation (exercise 2.4, 2a p. 97) $x^2 + 6x + 8$, the teacher may adjust it for learners to find a quadratic equation whose roots are -2 and -4. Learners come up with several different quadratic equations with the described roots. In addition, teachers could ask their learners to find the dimensions of a rectangle with an area of $30u^2$ instead of asking to find an area of a rectangle with sides $5u$ and $6u$. Learners would come up with several correct answers by exploring possibilities.

4.1.3 Ownership

The concern of ownership of knowledge is to unfold the experience of teachers if they are owners of the knowledge they teach. The interview results reveal ideas about teachers' measures and decisions to help their learners understand mathematics best.

Researcher: To what extent do you go beyond what is written in the textbook you teach to provide relevant tasks, especially when learners struggle to understand?

Teacher G1: *I teach only from the textbook and tell learners to read more.*

Teacher G2: *I do not even think of it; I teach what is written in the textbook. In the probability, I include the traditional game 'Shekut'; teaching learners real-world problems is fundamental, especially early. When the learners' minds mature, I do not think it is problematic to teach some unrealistic problems to check their computation skill level.*

Teacher P1: *yes, I include more examples not transcribed in the textbook, but I do not believe the examples assess understanding of the lesson but more on calculation.*

Teacher P2: *Conceptually, I did not go beyond the textbook, but I included more examples not included in the text to assess learners' understanding.*

Teacher N1: *I provide more examples that are not written in the textbook but are more procedural.*

Teacher N2: *The allocated time does not allow for doing so.*

Table 4. 3: Teachers' Ownership of Knowledge

Teacher	***School***	***Ownership of knowledge***
G1	*Government*	*No*
G2	*Government*	*Add indigenous knowledge*
P1	*Private*	*More examples*
P2	*Private*	*Additional examples*
N1	*NGO*	*More examples*
N2	*NGO*	*No, time limit*

Teachers P1, P2, and N1 of the six teachers respond by solving many problems (examples). On the contrary, previous research shows that learners do not learn much from repeating procedures (Adiredja & Louie, 2020). Similarly, teacher G1 strictly follows the textbook and informs learners to read more when they face difficulty. In the researcher's view, even though there are many materials to read, the role of the teacher should not be like teacher G1; the learners' primary source of their understanding (learning) in school is the teacher, not the textbook or other reference materials.

Teacher G2 explains that learners need to shape and train their minds at an early age with actual tasks. The teacher uses a game (indigenous game) to help learners understand the concept of probability. This teacher is the most experienced teacher of the participants, with 28 service years, and explains well what learners should learn early, as secondary school learners are teenagers. In contrast, teacher N2 thinks there is a lack of time to go beyond the textbook to help learners; therefore, he teaches like teacher G1. The researcher thinks the textbook has many repetitive examples and exercises; instead of wasting time to solve all these, teachers who think there are time constraints like N2 and G1 could change the nature of some questions. For example, the grade nine textbook has a Pythagoras theorem concept. Teachers could ask learners to find the distance between (-1, 2) and (2, 6) instead of providing right-angle triangle sides, which is common in the textbook.

4.1.4 Innovation

In the ICT era, a traditional teaching method (telling information) is not recommended. Previously, information was scarce; now, learners can get more information using their portable ICT devices in their homes without wasting time and resources to go to school. Therefore, teachers were asked in such a reality, what teaching techniques do you think are helpful for learners' learning? Here, the interview result reveals teachers' usage of teaching techniques, mainly alternative problem-solving techniques.

Researcher: How often do you show your learners alternative techniques for solving a single mathematical task?

Teacher G1: *In the grade nine textbook, in chapter two (solution of equations), there is more than one technique for solving quadratic equations and a system of linear equations in two variables. I show learners these techniques.*

Teacher G2: *Due to the time constraint, I teach alternative techniques written in the textbook. In the grade nine textbook, I show alternative approaches for solving quadratic and simultaneous equations, and in the grade ten textbook, chapter one is on zeros of polynomial functions.*

Teacher P1: *I show what is written in the textbook; for instance, when solving quadratic equations, I show learners how to use the quadratic formula and complete square method.*

Teacher P2: *Completing the square method and system of linear equations in two variables have alternative techniques to solve in the text, then I teach to my learners.*

Teacher N1: *In grade nine,* the *perfect square method and the quadratic formula to solve quadratic equations; substitution, elimination, and graphical methods to solve a system of linear* *equations in two variables; and in grade ten, solving zeros of polynomial functions I show alternative techniques.*

Teacher N2: *I teach what is written in the textbook, quadratic equations, simultaneous equations, and zeros of polynomial functions.*

Table 4. 4: Summary of the teacher's response on using alternative techniques of solving a single problem

Teacher	***School***	***Alternative techniques***
G1	*Government*	*Quadratic equations, the system of linear equations*
G2	*Government*	*Quadratic equation, simultaneous equation, and zeros of polynomials*
P1	*Private*	*Quadratic equation*
P2	*Private*	*Quadratic equation and system of linear equations*
N1	*NGO*	*Quadratic equation, the system of linear equations, zeros of polynomial functions*
N2	*NGO*	*Quadratic equations, simultaneous equations, zeros of polynomial functions*

The interview result in the summary of the above table reveals that teachers teach alternative techniques written in the textbook and do not go beyond that. Most teachers responded that they teach using alternative techniques on quadratic equations, simultaneous equations, and zeros of polynomial functions. These concepts are also presented in the textbook with alternative techniques. In the researcher's view, this teaching method may have worked in previous times when textbooks were scarce, but this problem is alleviated today. Learners could read and understand what is written in the textbook at their homes without coming to school. Therefore, teachers must go beyond the textbook to help their learners develop a deep understanding of mathematical concepts. Providing alternative problem-solving techniques helps to develop learners' creativity (Simamora & Saragih, 2019).

Teacher G2 from the government school reasons that there is a shortage of time, space, and resources to make the classroom active, participatory, and inclusive by letting learners search for additional techniques. Therefore, the teacher uses the teacher-centred instruction method and does not go far from the textbook techniques. However, to use the time effectively, teachers could minimize repetitive examples from the textbook and include relevant problems and alternative techniques from other sources, including websites.

4.1.5 Discussion of research question 1

The purpose of research question one was to unfold teachers' perceptions of creative teaching using Wood's four features of creative teaching as a lens. The teachers responded that they have experience applying these features except for the feature 'control.' Most participants respond as they try to connect school and out-of-school mathematics, provide additional examples and exercises, and show alternative problem-solving techniques (even these techniques are also in the textbooks). According to the teacher's response, they failed to open up closed problems as the textbooks are staffed with closed questions.

Four of the six teachers highlight that they try to connect school mathematics to out-of-school mathematics. These teachers took pedagogy during their pre-service training. Teachers who do not train in pedagogy responded that teacher G1 "*the textbook did not allow them to do so*'', and teacher N2's reply to the research question was ''make connections with day-to-day activities'' but failed to provide concrete examples. The teachers' responses reflect that the mathematics curriculum of grade 9 does not consider connection-making; as a result, mathematics is often taught as a collection of disconnected facts (LaMar & Boaler, 2021). The difference in the response of the teacher's interview may be due to the impact of pedagogy.

Connecting mathematics and real-world context, among concepts, procedures, and strands of mathematics in teaching, helps learners understand and appreciate the relevance of mathematics to their lives (Hatisaru, 2022). Connection-making may occur by connecting mathematical topics through expansion and inverse operation. For instance, the concept of fractions in Chapter 1 (let us see these similar fractions $\frac{4}{3}, \frac{8}{6}, \frac{16}{12}$) can be connected to the functions and relations of Chapter 4, whose slope is $\frac{4}{3}$ ($y = \frac{4}{3}x,\ whose\ coordinates\ are\ (x, y) = (3, 4), (6, 8), (12, 16)$), to a set of ordered pairs in chapter three (sets), connecting each x-coordinate with the graph $y = \frac{4}{3}x$, where x is 3, 4, and 6, could be connected to chapter five, with enlargement or transformation geometry (similar triangles with sides, 3,4,5: 6, 8, 10; and 12, 16, 20)

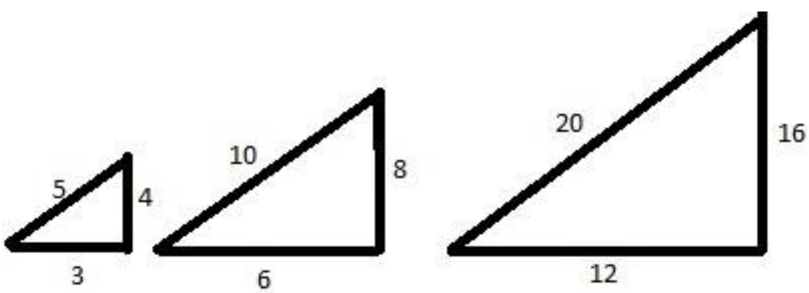


Figure 4. 1: Transformation Geometry

This transformation geometry is also connected to the Pythagorean Theorem (Chapter Two), the frequency distribution of Chapter Six (statistics and probability), and the representation of vectors in Chapter Seven (vectors in two dimensions). Therefore, mathematics is a connected subject; teachers must use their imagination to make connections among mathematics concepts. The curriculum standards do not present the topics as related and integrated ideas.

Designing open problems helps learners to come up with different brain paths. When learners work on open problems, they explore various possibilities, make connections among concepts, and find the correct answers (Boaler, 2015). The teacher's role is to design the problem, let learners solve it, and then manage the classroom. Unfortunately, all the teachers failed to design open mathematical tasks, and teacher P1 considered the word problems as open questions. This trend of teachers is also observed in the study conducted by (Klein & Leikin, 2020, p.361), who concluded that ‘‘although open mathematical tasks (OTs) are considered a powerful creativity-directed activity, their use in mathematics classes is unusual.’’

Teachers are not expected to dictate what is written in the textbooks only. They must show considerable ownership of the knowledge they teach by addressing mathematical issues beyond the textbooks and within the boundaries of curriculum requirements. This (ownership of knowledge) teacher’s behaviour or activity positively influences learners' achievement (Harisman, Kusumah & Kusnandi, 2019). Most teachers responded by providing additional examples not written in the textbooks (teachers P1, P2, & N1). As in the textbook, these additional examples should not be repetitive; there should be some adjustment, as teachers must teach their learners deep, transferable, and creative knowledge. Teacher G2 includes indigenous mathematics knowledge, and this is what is required. Teacher G2 uses his imagination to connect school and out-of-school mathematics. However, teachers G1 and N2 teach what is written in the textbooks. These teachers put aside their thinking and use the work of others with their deficiencies to teach their learners. In the researcher’s opinion, teachers should use their imagination, thinking, and intuition in preparing relevant mathematical tasks for their learners.

In addition, teachers must devise alternative techniques for solving a single problem. This method motivates learners to find optimal solutions other than imitating the teacher's words (guided discovery). Innovative teaching inspires teachers to promote new ideas and gain novel experiences (Cevikbas & Kaiser, 2020). Teachers’ interview results reveal that they show their learners alternative techniques written in textbooks.

4.1.6 Summary of Research Question 1

Through this question, an attempt was made to explore teachers’ conceptions of creative teaching. Most teachers have limited experience in creative teaching practices. All the experiences they describe were in line with what is written in the textbooks except for the teacher

G2’s response ‘‘Shekut’’, a traditional probability game. Hence, teachers lack relevance, control, ownership, and innovation in teaching as they transmit what is written in the textbooks. This trend reflects how they were trained during pre-service training and negatively impacts learners' understanding of mathematics.

In addition, the teacher interview result shows that teachers' teaching methods were influenced by the textbook's style of presenting the topic. All interviewed teachers responded that they teach in the way the textbooks present the topic. The purpose of the next question was to assess whether secondary school mathematics textbooks help teachers to teach creatively or not.

4.2 Research Question 2

How do the official textbook and suggested teaching materials used in teaching mathematics relate to teachers’ and learners’ real-life contexts?

In answering this research question, data were gathered from document analysis of grade nine mathematics learner textbooks and a semi-structured one-on-one interview with six mathematics teachers. The textbook’s name is ‘‘mathematics student textbook grade 9’’. This textbook was chosen since grade 9 is the level of transition from elementary to secondary and, for most Ethiopians, from their mother tongue language to English as a medium of instruction. Language change affects learners' understanding of the subject (Kassa & Abebe, 2022); therefore, it must be presented meaningfully to help teachers support their learners.

The grade nine official learners’ textbooks for teaching and learning mathematics were evaluated using Wood’s four features of creative teaching in terms of Cremin’s dimensions of creative teaching. The aspects evaluated in this section include how lessons are introduced, concept development, the nature of tasks presented, and the impact of the textbook on teachers' personal quality, pedagogy, and classroom ethos. The collected data was analysed and discussed under the following themes: relevance, control, ownership, and innovation regarding personal quality, pedagogy, and classroom ethos.

I) Document analysis

4.2.1 Relevance of the textbook

Personal quality: The textbook’s methods of presenting topics impact teachers’ personal quality (Rezat, Fan & Pepin, 2021). Teachers are implementers of textbook ideas during their teaching. Therefore, they reflect the textbook's method of presenting mathematics concepts during their teaching. In creative teaching, teachers need to know the background of their learners and construct teaching based on their learner’s backgrounds. Grade nine textbook does not support teachers in understanding learners’ interests, backgrounds, and cultures. For instance, the concept of binary numbers is missed in the number system (unit 1). Computers and machines use combinations of 0 and 1 to communicate with humans. Therefore, the knowledge of binary numbers is essential in this ICT era. Ethiopian indigenous society uses this indigenous mathematics knowledge in marketplaces to execute the fair price of goods, as said in the literature. In addition, in the textbook's probability and statistics section (chapter 6), even though several traditional games need to be included, such as ‘Shekut,’ the textbook does not consider them; instead, it comes with dice, which are strange to both teachers and learners. The following sample problem is in the probability and statistics chapter review exercise (p. 290), which says:

> **15** Suppose you write the days of the week on identical pieces of paper. You mix them in a bowl and select one at a time. What is the probability that the day you select will have the letter r in it?

There is no relevance in counting the number of r’s in the name of days of a week other than wasting time and resources. Here, teachers and learners perceive mathematics as far from reality, and its most significant concern is blind calculation without looking at reality. This textbook tradition denies teachers the ability to use their imagination to connect school mathematics to learners' authentic lives, enabling learners to engage in their learning easily.

Pedagogically: Chapters of the textbook are not presented meaningfully in terms of their sequence. Textbook authors give little attention to the sequence of topics (Petersson et al., 2021). It may make more sense if the number system (Chapter One) is followed by Sets (Chapter 3). The common factors and common multiples could be related to unions and intersections of sets. The expansion nature of number systems, such as natural numbers to whole numbers, whole numbers to integers, rational and irrational numbers, real numbers, and complex numbers, would connect to sets as one is the subset of the other. However, in the textbook, following the number system in chapter one, chapter two is the solution of equations. It is difficult for teachers and learners to transfer from one concept to another. Chapter Five is about geometry and measurement, Chapter Six is about statistics and probability, and Chapter Seven is about vectors in two dimensions. There is no connection in transferring from chapters five to six and then to seven. The researcher thinks it would be good if geometry and measurement were followed by vectors in two dimensions and then statistics and probability.

Connection-making is the key to coherent mental schemas that underlie deep understanding, creative and transferable knowledge, and skills (Fries et al., 2021). However, connections between the school and out-of-school experience of teachers and learners in the textbook are also made in a false context. Word problems at the end of each chapter are considered a means for connection-making between school and out-of-school mathematics. Therefore, the textbook's concern should be letting teachers and learners model a problem by providing real data or engaging teachers and learners in relevant problems. However, all textbook questions that need modelling are already modelled; the authors solve the cognitive aspect of word problems. For instance, let us see the problems in the chapter four review exercises (p.174):

21 A mobile phone technician uses the linear function $c(t) = 2t + 15$ to determine the cost of repair, where t is the time in hours and $c(t)$ the cost in Birr. How much will you pay if it takes him 3 hours to repair your mobile?

Teachers depend more on the textbook (Yaro, Amoah, & Wagner, 2020). They solve this problem without realizing its impact on learners' perception of mathematics. The task is modelled in a false context; even considering it real, its cognitive aspect is already done (modelled). Most of the time, the repair cost depends on the type of accessory needed to be replaced rather than on the time it is consumed to repair. Teachers and learners could solve it by ignoring real assumptions. Therefore, textbook problems are not helpful for teachers to teach creatively.

Classroom ethos: In a creative teaching classroom, a working together environment would be created if there is a connection between the school and the out–of–school experience of learners. The collaborative engagement bi-directionally enhances connection-making (Lubicz-Nawrocka, 2023). In chapter one, in the topic limits of accuracy, the solved examples and exercises are in an abstract context. There is no relevance to rounding the number 8.9 to 9. The context to round up a number is not described in the textbook. Therefore, this could be made meaningful by slight adjustment, say: There are 356 learners in a school, the capacity of a single school bus is 40 learners, how many buses are needed? In solving this question, learners performed the usual division and got 8.9 buses. However, this answer is unrealistic since there is no such number of buses; therefore, learners realized that they must round up the number of buses to 9.

4.2.2 Ownership

Personal quality: Teachers are expected to understand the subject they teach sincerely and should not act like knowledge-transmitting machines. The textbook can help teachers have that competency by allowing them to solve problems using their methods, as teachers are considered owners of the creative knowledge they teach. This autonomy could be achieved by not providing solution manuals to the textbook exercises. Here, teachers struggle and focus more on why? in solving questions and may make adjustments when they think the question is unrealistic. Unfortunately, this trend is not seen in grade nine mathematics teaching materials. Even if there are difficult questions, such as in the chapter five review exercise (p.248)

19 An agriculture field is rectangular, with dimensions 100 m by 42 m. A 20 m deep well of diameter 14 m is dug in a corner of the field and the earth taken out is spread evenly over the remaining part of the field. Find the increase in the level of the field.

The teachers' guide prepared at the national level has all the solutions. In the researcher's opinion, giving a solution to problems is not a good idea. Providing a solution for teachers may indicate that the education system does not believe in the teachers' competence. Even though it does not say clearly, this curriculum has a clear and loud message: teachers are not owners of the subject they teach. Consequently, teachers may believe they are not owners of the knowledge they teach because the owner provides them with the exercise solution manual, and they must transfer it effectively. Artificial intelligence (AI), such as Chat Gpt and Bing Chat, is another recent global challenge. Put the above question in Bing Chat; the following response will be generated immediately.

The volume of earth removed from the well is given by:

$$V_{well} = \frac{\pi}{4}d^2h = \frac{\pi}{4}(14)^2(20) = 3080\pi$$

The area of the remaining part of the field is given by:

$$A_{field} = l \times b - A_{well} = (100 \times 42) - \frac{\pi}{4}(14)^2 = 4200 -$$

where l and b are length and breadth of field respectively.

Therefore, increase in level of field is given by:

$$\Delta h = \frac{V_{well}}{A_{field}} = \frac{3080\pi}{3584} \approx 2.72m$$

So, there will be an increase in level of approximately **2.72 meters**.

Figure 4. 2: An answer for the above question from Bing Chat

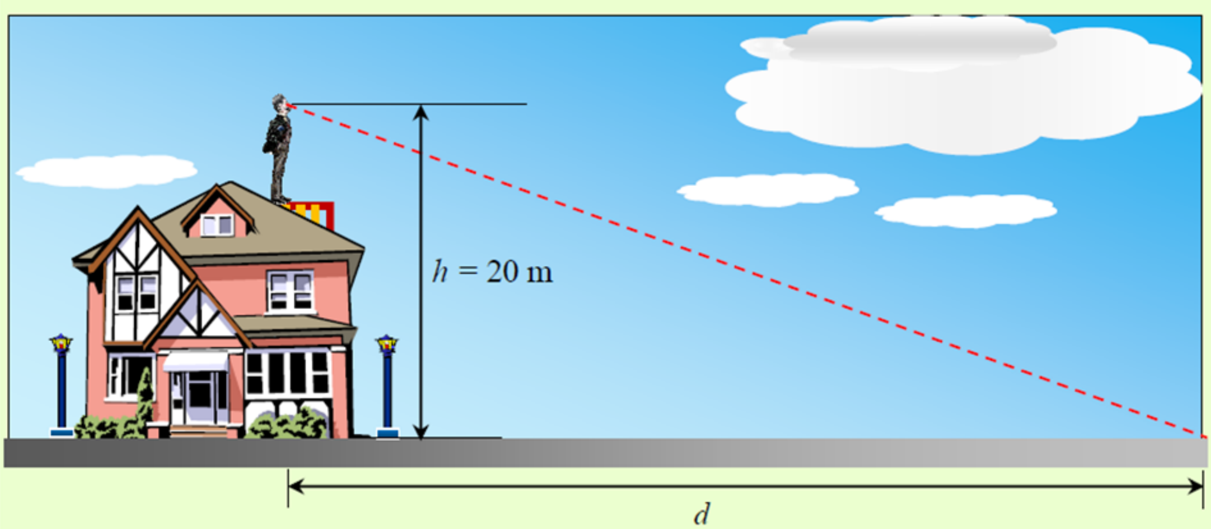
Even though the answer is incorrect, the steps followed by the system are correct. The mistake comes from an arithmetic error.

$A_{field=total\ area-area\ of\ the\ well,}\ \ 4200-154=4046m^2,\ \ and\ V_{well}=\pi r^2h=\pi(7)^2 20=3080m^3$

then $\Delta h = \frac{V_{well}}{A_{field}} = \frac{3080}{4046} \approx 0.76m$. The researcher believes the Ethiopian Ministry of Education should consider these interruptions in the education system. They are taking ownership of knowledge unconsciously.

Pedagogically: As said before, the review exercise at the end of every chapter represents the big picture of each chapter. Therefore, in this theme, the review exercise was evaluated. Drawing helps to visualize, understand, and solve complex problems (Hawes, Moss, Caswell, Seo & Ansari, 2019), especially real-world questions (Schukajlow, Blomberg, Rellensmann, & Leopold, 2022). The grade 9 textbook does not provide good experience in drawing mathematical tasks. Chapter one has the only review exercise presented by translating the word problem into drawing throughout the textbook (p.62).

15 The formula $d = 3.56\sqrt{h}$ km estimates the distance a person can see to the horizon, where h is the height of the eyes of the person from the ground in metre. Suppose you are in a building such that your eye level is 20 m above the ground. Estimate how far you can see to the horizon.



In the researcher's view, even this question is not challenging, which is solved by direct substitution; drawing helps teachers and learners develop the skill of drawing a problem to visualize, understand, and solve it. In the researcher's opinion, the textbook must not draw all the problems; this should be the role of teachers and learners, but it should show to some degree.

Even though several problems need drawing to visualize, the textbook does not. For example, the sample exercises in the textbook unit two review exercise (p. 104) would be more understandable if the problems were sketched but not done.

14 An object is thrown vertically upward from a height of h_o ft with an initial speed of v_o ft/sec. Its height h (in feet) after t seconds is given by $h = -16t^2 + v_o t + h_o$. Given this, if it is thrown vertically upward from the ground with an initial speed of 64 ft/sec,

a At what time will the height of the ball be 15 ft? (two answers)

b How long will it take for the ball to reach 63 ft?

Classroom ethos: The textbook's knowledge must be meaningful for teachers and learners. Relevant knowledge helps teachers become owners of the knowledge they teach, and learners learn for themselves, not for the examination. Knowledge becomes meaningful to them within their frame of reference, not dictated by external assessment. Therefore, learners would have shared responsibility for their learning (Bovill, 2020). Unfortunately, the textbook does not provide the content and task relevantly in a way that makes teachers and learners believe that the knowledge in the textbook is meaningful for them (Gebremichael, 2019). Instead, it provides procedures to be followed in solving problems. The following sample rules were given to solve quadratic equations in the textbook (p.92).

In general, go through the following steps in order to solve a quadratic equation by the method of completing the square:

i Write the given quadratic equation in the standard form.

ii Make the coefficient of x^2 unity, if it is not.

iii Shift the constant term to R.H.S.(Right Hand Side)

iv Add $\left(\frac{1}{2}\text{coefficient of } x\right)^2$ on both sides.

v Express L.H.S.(Left Hand Side) as the perfect square of a suitable binomial expression and simplify the R.H.S.

vi Take square root of both the sides.

vii Obtain the values of x by shifting the constant term from L.H.S. to R.H.S.

(Grade 9 mathematics textbook p.92)

The researcher believes that learners could try to memorize these steps only for the examination. After that, they would not remember all these seven steps, even those higher achievers. A study by Sawyer (2019) confirms this: Learners could only have shallow knowledge in such procedural teaching without reasoning.

4.2.3 Control

Personal quality: Teachers' responsiveness to learners' opinions and situations is influenced by the textbook's nature of presenting the lessons. The textbook's questioning stance helps teachers assess learners' previous conceptions and construct and individualize teaching in response to learners understanding (Denessen et al., 2020). According to Thanheiser and Melhuish (2023, p.5), ''*Conferring to Understand Student Thinking and Reasoning is at the core of student-centred instruction as teachers need to access student mathematical thinking to allow them to work with it.*'' However, there is not a single introducing question throughout the textbook. Even though there are several class activities and group discussions in the textbook, they follow the formulas and examples. That means after learners are informed how to think.

Pedagogically: The textbooks must start every topic by asking and encouraging learners to pose questions. Textbook questions must be open to help learners develop different correct methods and answers. Solving open mathematical tasks is a powerful creativity-directed activity (Klein & Leikin, 2020). Here, teachers should not rush to answer the questions and must provide enough time for learners to struggle. Unfortunately, almost all the textbook chapters do not have open questions. Activities and group work follow every topic; the problem is that they are all closed. Most of the time, they have one right way and one correct answer, procedural and irrelevant. Open tasks such as in group work 1.1 (p.4) support creative teaching and learning because learners come with several correct answers and methods but are a minority of questions (rare) in the textbook. In the researcher's view, limiting only to natural numbers in solving this problem is not good; teachers and learners should search for the answer without any limit.

2 The area of a rectangle is 432 sq. units. The measurements of the length and width of the rectangle are expressed by natural numbers.

Find all the possible dimensions (length and width) of the rectangle.

Classroom ethos: Teachers and learners must be learning partners (Carless, 2020) in creative teaching classrooms. In helping this trend, the textbook should design open mathematical tasks that are familiar to teachers and learners. In such an environment, both teachers and learners share their ideas and defend their methods, and the possibility of thinking would flourish; teachers and learners would have the chance to use different mechanisms in solving and defending their way of solving problems. However, the textbook is staffed with closed and predetermined problems. The mathematical tasks in the textbook are all closed; hence, there is no space for divergent thinking. In the chapter three review exercise (p. 138), the word problem considered challenging to learners thinking and collaboration is counting the number of letters preceding the letter 'v' in the English alphabet.

14 How many letters in the English alphabet precede the letter *v*? (Think of a shortcut method).

Learners thinking cannot grow with such questions; it may require counting from V to Z using their fingers and subtracting from the total English alphabet to solve, which is primitive. Therefore, the textbook is not supportive of making the classroom environment interactive. An active classroom ethos is created by engaging learners in challenging questions about what they experience in their real lives.

Other questions are even true or false questions; the following question in unit 5 (p.202) is not the only true or false type question in the textbook but a sample.

Exercise 5.5

1 State whether each of the following statements is true or false.

a If two triangles are similar, then they are congruent.

b If two triangles are congruent, then they are similar.

c All equilateral triangles are congruent.

d All equilateral triangles are similar.

The researcher doubts what kind of classroom ethos the teacher would create with such questions.

4.2.4 Innovation

Personal quality: The textbook must be prepared so teachers feel creative knowledge owners. Creative teaching results from combining general ideas (Rosyadi, Sa'dijah & Rahardjo, 2022); the textbook should provide challenging tasks requiring combinations of different problem-solving concepts. These questions require a multifaceted set of teacher skills (Strohmaier et al., 2022). Combining different methods allows teachers to master and understand the content (Boaler et al., 2021). It also allows a productive and meaningful exchange between different sections of mathematical disciplines (Hawes, Merkley, Stager, & Ansari, 2021). However, the chapters do not connect with the preceding ideas in solving tasks using different concepts. Every task is solved using only the current concept, not combining various previous ideas. As teachers follow the textbook approaches, their creative teaching skill is suppressed.

Pedagogically: Providing alternative textbook techniques motivates teachers' and learners' creativity (Kusuma, Jefri, Hidayat & Hamidah, 2020). Throughout the book, only three concepts are presented with alternative problem-solving techniques. These are the greatest common factor and least common multiple by listing and prime factorization method. The second one is solving a system of linear equations in two variables by graphical method, substitution, and elimination method. The third one is solving quadratic equations using factorizations, completing the square method, and the quadratic formula. The other portion of the textbook tasks has only one method of solving to arrive at the single correct solution. This technique does not help to cultivate creativity, as divergent thinking is not considered or valued in the textbook.

Classroom ethos: The classroom should provide choices of learning for learners. In the technologically rich era, teachers must also be well-equipped with learning choices (Abdul-Razak, 2020). The primary source of learning choices must be the textbook. Unfortunately, it does not instruct teachers in using models, technologies, or artefacts to help learners understand mathematics well. The textbook shows only one technique to arrive at the one correct answer; here, learners have no choice in visualizing, understanding and solving problems other than following only the dictates of the textbook. This textbook approach does not help teachers and learners; hence creativity.

II) Interview

An interview was conducted to see teachers' perceptions of the textbooks they teach. Wood's four innovative teaching features were used as a lens in developing the interview questions. The result was discussed under relevance, ownership, control, and innovation.

4.2.5 Relevance

In this subtheme, teachers were asked to share their perceptions of the relevance of the textbook tasks. The relevance of the textbook tasks helps teachers teach flexibly and creatively, and learners retain, upgrade, and apply the knowledge flexibly in new situations.

Researcher: How do you see the relevance of the textbook tasks as the primary teaching material to the lives of teachers and learners?

Teacher G1: *It is not supportive of teaching relevantly.*

Teacher G2: *Most of the portion is not presented relevantly, but some tasks in statistics and probability relate to real-life situations in finding mean median and standard deviations.*

Teacher P1: *Not relevant; the topics are good, but the tasks are not prepared relevantly.*

Teacher P2: *It is not relevant. Of course, chapter six has some topics related to our lives, such as statistics and probability. If we see the big picture of the book's task, it is not presented relevantly.*

Teacher N1: *It is not presented relevantly for teachers and learners; it looks like teachers are responsible for making it relevant.*

Teacher N2: *Not relevant; it is not more than arithmetic.*

Table 4. 5: Teacher's Perception of the Relevance of Grade Nine Mathematics Textbook Tasks

Teacher	School	Relevance of tasks
G1	Government	Not relevant
G2	Government	Partially relevant
P1	Private	Not relevant
P2	Private	Partially relevant
N1	NGO	Not relevant
N2	NGO	Not relevant

Out of the six teachers interviewed, four indicated that textbook tasks are not relevant to the lives of teachers and learners. The researcher thinks that this teacher's response is due to the nature of the textbook tasks, as discussed before in the textbook analysis. Only teacher G2 from a government school and teacher P2 from a private school say it is partially relevant. These two teachers refer to probability and statistics as relevant in finding mean, median, and standard deviation. Even these two teachers are not satisfied with the tasks of the textbook. The role of teachers is then to execute calculations using the formulas provided without understanding the topic's aim. Following this, they consider mathematics an irrelevant and abstract subject. They could not connect to their lives, focusing more on memorising formulas and procedures than concepts. A perceived lack of relevance can result in disinterest and even disengagement with mathematics entirely (Fitzmaurice, O'Meara & Johnson, 2021).

4.2.6 Ownership

Difficult questions open the way for teachers' ownership of the knowledge they teach. When the tasks are challenging, teachers see all their possibilities by combining their previous knowledge to solve them. As a result, they become owners of the knowledge that they teach. Teachers were asked if the textbooks provided challenging tasks.

How do you see the textbooks in designing challenging problems?

Teacher G1*:* *The textbook has a good experience with challenging questions in word problems*

Teacher G2: *The text has some challenging problems, but most questions need memorizing formulas and procedures. For example, the tasks in chapter five (geometry and measurement) are easily presented; the biggest concern is memorizing formulas; as a result, students fail to retain them.*

Teacher P1: *The textbook word problems are challenging but solved in the teacher's guide.*

Teacher P2: *A minority of questions are challenging; most textbook questions are trivial and repetitive, requiring memorizing formulas.*

Teacher N1: *Although challenging questions are in the textbooks, their solutions are available in the teacher's guide. Therefore, it may challenge students but not teachers.*

Teacher N2: *There are challenging questions, especially word problems.*

Challenging questions help teachers and learners develop ownership of the knowledge they teach and learn and make their thinking visible (Ingram et al., 2020). Three out of the six teachers (teachers G1, P1, N2) responded that word problems are the most challenging tasks in the textbook. The word problems are a minority of the questions in the textbook (P2, G2), and they are solved in the teacher's guide (P1, N1). These problems may be challenging for learners (N1) only if teachers do not act like solution manuals. From the teachers' response, the textbook as a teaching material does not help support teachers towards ownership of the knowledge they teach.

4.2.7 Control

Designing questions with multiple answers and different ways to solve them in the textbook helps teachers with learner-centred instruction. The researcher believes the textbook could encourage a learner-centred teaching approach by introducing every new topic through questions and learner activity. However, from the document analysis result above, most questions are closed, with only one answer and one right way. The teachers were asked for their conceptions of the textbook in designing mathematical tasks.

Researcher: How do you see the textbooks in designing tasks to make learners active participants?

Teacher G1: *The designed tasks do not support creating an active classroom environment. Even though there are several activity and group discussion questions in the text, they require remembering formulas, definitions, or procedures instead of conceptual understanding and intuition of learners.*

Teacher G2: *The textbook task design focuses on quantity rather than quality. There are many activity questions; some are to define, others to list properties to categorise. There are also true* *and false questions in the activity and group discussion problems, and they are also repetitive. It is about memorizing, not understanding; learners cannot contribute, defend their ideas, and challenge their learning.*

Teacher P1: *There are questions in the textbook that are unsupportive of active teaching and learning because of their closed nature.*

Teacher P2: *Open questions with several correct answers help learners' active participation, but the textbook tasks are closed and not helpful for active learning.*

Teacher N1: *Questions connected to learners' authentic lives help for an active classroom. However, textbook tasks do not have this quality. Therefore, they are not helpful as learners cannot participate meaningfully in abstract ideas more than memorizing facts.*

Teacher N2: *Several questions in the textbook lack relevance to learners' conceptual understanding and hence are not supportive of active participation of learners as they require memorization of rules and are also repetitive.*

From the teachers' responses, all six teachers believe that the questions in the textbooks are not designed well for the active participation of learners. Teacher G1 from the government school says the textbook questions are not asking for conceptual understanding of learners but memorizing facts. Teacher G2 in the same school said the textbook provided several activities and tasks but focused on memorizing facts rather than a conceptual understanding of learners.

Teachers from private schools have similar stances as government school teachers. Teachers P1 and P2 think that open problems with several correct answers help create an active teaching and learning environment because learners come with many methods and answers. The textbook tasks are not designed to open mathematical tasks and hence lack to help active learners' participation. Teacher N1 from the NGO school focuses on the tasks that should be connected to learners' lives in creating a participatory classroom, but the big picture of textbook questions is far from connection-making in designing tasks. Teacher N2 responds that based on the textbook trend, memorization and repetition of problems are the value paid to help teachers and learners understand mathematics; therefore, they are not supportive of creating an active classroom environment.

From the teacher's interview result, the following summary could be done. The teachers believe that for the active participation of learners, the textbook tasks should be relevant to learners' lives (N1). When connection-making is impossible, it cannot always be done; the questions must be open to help learners develop different methods and answers (P1 & P2). The tasks also must not be repetitive as learners cannot learn from repetitive problems (G1&N2). The textbook authors should consider these shortcomings listed by teachers.

4.2.8 Innovation

The textbook is the primary teaching material in the classroom. Teachers were asked if the textbook provides alternative solution methods for problems and examples. The alternative solution method encourages teachers and learners to be creative in finding other optimal methods for solving problems. The teacher's response was as seen below.

Researcher: How do you see the frequency of the textbook in providing alternative problem-solving techniques?

Teacher G1: *Rarely, such as in quadratic equations.*

Teacher G2: *Almost only on quadratic equations and a system of linear equations. The other chapters provide only one way of solving questions.*

Teacher P1: *The textbook does not provide alternative techniques.*

Teacher P2: *A few topics, commonly the quadratic equation*

Teacher N1: *In a quadratic equation, the textbook shows alternative techniques, not on other topics.*

Teacher N2: *It is rare*

From the teacher's response above, teachers are unsatisfied with the textbook's frequency of providing alternative problem-solving techniques. Teacher G1 from the government school responds that the textbook rarely provides alternative techniques, such as in quadratic equations. In contrast, teacher G2 from the same school explains two topics with alternative techniques in grade nine textbooks. The other ones have only one way of solving the problems in the textbook.

More or fewer teachers, P1 and N2, respond similarly to teacher G1. Teachers P2 and N1 say the quadratic equation topic has alternative techniques. From the teacher's interview results, almost all of the tasks in the grade nine textbook have only one method of solving the provided tasks. The only topics with alternative techniques are quadratic equations and a system of linear equations.

4.2.9 Discussion of Research Question 2

This section's most concern was exploring the relevance of the textbook tasks. In addition, the trend of the textbooks in providing alternative techniques of solving problems, opening closed problems, and providing challenging tasks are also explored. In the interview part, the researcher explores the teachers' thoughts on the textbook. Teachers believe that most of the textbook tasks are presented irrelevantly. A few tasks in the text are relevant; for instance, some tasks in statistics and probability are good for finding mean, median, and standard deviations, but the big picture of the other chapters' tasks in the grade nine mathematics textbook is irrelevant.

In the document analysis section, the researcher focuses on the relevance of textbook tasks and challenging tasks, open problems, and on providing alternative problem-solving techniques. Relevance in this study's context was explored, whether the textbook contents and tasks are presented as an integrated whole, helping teachers and learners model situations by providing real data in a real context. When the content and task are relevant, teachers and learners are easily engaged in solving the problems without any external pressure. Relevant tasks are solved by considering real assumptions, not in a false context, hence meaningful to the lives of teachers and learners. Unfortunately, the textbook does not consider making connections between chapters, among subjects, and school and out-of-school mathematics. The authors of the textbook already model the mathematical tasks that need to be done by teachers and learners. The concepts and tasks are presented as separated fractions, not as an integrated whole subject. Most tasks are meaningless, as discussed earlier in the document analysis. Solving such problems has no real-life relevance but may only be important in the school context (Verschaffel, Schukajlow, Star, & Van Dooren, 2020).

Teachers' ownership over their work and immersing themselves in mathematics- and teaching-relevant problems seemed to catalyze higher-level thinking and conversation (Bosica, Pyper & MacGregor, 2021). The teaching materials must be prepared in the way teachers feel as owners of the subject they teach. Providing freedom for teachers, for instance, to use their method in solving questions is one way. Flexible problem-solving builds teachers' confidence and can develop the skill of posing new questions to their learners as they are owners of the knowledge they teach. Unfortunately, the education system seems not to believe in the competence of teachers. The teacher guide prepared at a national level has all the solutions for the tasks in the textbook. Hence, teachers may not think of themselves as owners of the subject they teach because the owner provides all the solutions, and their role is to transmit what is said in the textbook and teachers' guide effectively.

The textbook also shows that the tasks have only one way of reaching the correct answer. The tasks in the textbooks are solved using predetermined equations such as formulas of the quadratic equation. There is no diversity of right ways and answers, which help teachers and learners develop different brain paths. This trend fails to cultivate the creativity of teachers and learners (Leikin & Elgrably, 2022) and forces teachers to put aside their thinking and dictate what is written in the textbooks. The instruction system with such a textbook could be predicted to become more or less teacher-centred as it defines the definition, puts the rules and formulas, and provides examples and exercises to be solved using these formulas.

4.2.10 Summary of Research Question Two

From the findings discussed above, the following conclusion could be made. The teacher interviews and document analysis revealed that the textbook tasks are not presented relevantly. The big pictures of the textbook tasks are more or less staffed with predetermined equations. There are formulas, rules, and procedures to be followed to solve problems; there is no way to deviate from these regulations to see other options. In solving textbook problems, teachers and learners must memorize the formula, follow the prescribed rules, and reach the predetermined last solution. In addition, the textbooks do not provide alternative problem-solving techniques other than in quadratic equations and simultaneous equations. In addition, all problems are closed; they have only one correct method and answer. Research studies indicate that mathematical tasks should be open to follow different methods and to reach various correct answers (Klein & Leikin, 2020). Therefore, the textbook does not support boosting teachers' personal quality, pedagogy, and ethos of creative teaching in the classroom.

Teachers' perception of creative teaching in research question one and how the textbook presented contents and tasks in research question two have been discussed. How teachers practice the textbook in their natural setting is the issue of the following research question.

4.3 Research Question 3

To what extent do mathematics teachers apply creative teaching practices in their classrooms?

In this section, the researcher presents the research results from lesson observation, document analysis, and an interview. The lessons of three teachers were observed in three secondary schools. The syllabus and lesson plan used in the observed class were also analyzed, and an interview was conducted with six mathematics teachers.

I) Pre-lesson observation interview

In this subsection, teachers were asked what they think of creative teaching. Teachers try to work according to their conception, so it is essential to understand what teachers think of creative teaching. This research question is discussed under the theme of creative teaching.

4.3.1 Creative Teaching

Creative teaching is an instructional technique that helps teachers and learners understand the topic's relevance and use it flexibly in new situations. Through this technique, learners would be creative, deep, and transferable knowledge owners.

Researcher: what is creative teaching to you?

Teacher G1: *Creative teaching is a technique that helps learners understand the lesson best and use it flexibly in new situations.*

Teacher G2: *Creative teaching is concept teaching using different techniques.*

Teacher P1: *Creative teaching is a teaching style that helps learners to collaborate, communicate, and contribute, and these learners' activities lead teachers to choose the best teaching technique.*

Teacher P2: *Creative teaching is a teaching style that focuses on the topic's concepts, aims, and objectives.*

Teacher N1: *It is a teaching method that is not pre-planned but spontaneous and starts by asking questions and constructs the technique based on learners' responses.*

Teacher N2: *This teaching style cultivates learners' deep learning, critical thinking, and problem-solving.*

Table 4. 6: Conception of Teachers for Creative Teaching

Teacher	School	Perception of creative teaching
G1	Government	Teaching transferable knowledge
G2	Government	Concept teaching
P1	Private	Spontaneous
P2	Private	Concept teaching
N1	NGO	Spontaneous
N2	NGO	Critical thinking, deep learning, and problem-solving

The essence of the teacher's response was that creative teaching is concept teaching, as indicated in the table above. The response from the government school teacher G1 indicates that a teaching method is considered creative if it helps learners apply it in ‘new situations.’ Teacher G2 says it is a concept teaching, and its concern is not on rules and procedures but on concepts. The spirit of the two government school teachers is similar in that creative teaching is concept teaching, even the difference in qualification as indicated in Table 3.1 in the previous chapter.

Teacher P1 from a private school says creative teaching begins from the learner’s conception of the topic. For teacher P1, teachers need to ask questions when introducing the new lesson and let the learners discuss; the teacher should draw how to teach from the learners’ understanding of the topic. Similarly, teacher P2's emphasis on creative teaching is concept teaching. In the response of the two teachers, there is no significant difference.

The interview result from the NGO school teacher N1 responds that creative teaching is a process. It is constructed on learners’ response and understanding to the introducing question asked by the teacher. Teacher N2 says the concern of creative teaching is learners’ deep understanding of the topic rather than shallow knowledge that could not be retained. The difference between the two teachers’ responses is that teacher N1 (professional teacher), who has a Bed in mathematics, clarifies what creative teaching means well. At the same time, teacher N2, who graduates with a BSc degree in mathematics, comes with the focus area of creative teachings, such as deep learning, critical thinking, and problem-solving. However, research shows that teachers lack the necessary education, pedagogy, personal quality, and classroom management strategy to create such an environment (Kandemir, Tezci, Shelley, & Demirli, 2019).

II) Lesson Observation

In the observation session, the researcher uses Cremin’s three dimensions of creative teaching as a framework to collect data. Based on this framework, the teachers must explain the lesson's relevance to the learners. Following that, the teacher asks a question, and in solving this question, learners need to collaborate. Additionally, the classroom needs to be resourceful so that learners can use their choice of tools to solve the problem. Then, they (the collaboration group) must individually justify their answers to the class. Hence, the teachers use learners' contributions and new ideas as input to help them.

Lesson observation was conducted in one class in each of the three schools, and the researcher presented and analyzed the experience of three teachers from each school.

4.3.2 Usual Methods of Teaching

In this subtopic, data collected from lesson observation was presented and analyzed. Under this theme, lesson observations of teachers P2, N1, and G1 were presented. The teaching styles teachers apply, as observed by the researcher, were usual and procedural. The observed lessons are discussed under personal quality, pedagogy, and classroom ethos.

Teacher P2 lesson observation

Name of school: School P (private school)

Subject: Mathematics

Class: 9B

Observed lesson topic: Solving system of linear equations by elimination method

Period: 3

Duration: 45 minutes

Date: 01Dec, 2021

Teacher P2: *Take your mathematics exercise books and open to page 74. Yesterday, we learned about solving a system of linear equations using the substitution method.*

Teacher P2*: Can someone tell us how to solve simultaneous equations in two variables using the substitution method?*

(Learners were silent and rushed to find its procedures in their textbook.)

Teacher P2*: Remembering the procedures is difficult, but you should grasp the concept.* (There was silence again)

Teacher P2*: please listen to me; there are three steps in solving using the substitution method. The first one is expressing one variable in terms of the second variable. Substitute your result into the other equation and solve for the second variable. Finally, substitute this result into one of the equations and solve for the first variable. These are the ideas of the substitution method. Today, we will see another technique for solving linear equations in two variables: the elimination method. This method is the third; in the previous class, we discuss the graphical and substitution methods.*

Teacher P2: *by the way, what steps should be followed in solving using the graphical method?*

Student 1*:* Raised his hands to tell the teacher that we first need*ed to sketch the line of the two variables. If they intersect at one point, they have a unique solution at the point of intersection.*

Teacher P2*: Good, you have gone half of the way. The graphical method helps to identify the nature of the solution. If the two lines are parallel (do not intersect), the system has no solution; if one line fits over the other, the system will have infinitely many solutions.*

Then, the teacher introduced the steps to solve using the elimination method (the new topic) and solved two questions as an example. The teacher then gives a classwork exercise to teach learners how to solve using the elimination method. The teacher asks the learners who is the first to tell me the answer. The teacher checks each learner's answer by saying ‘yes’ if the answer is correct and ‘no’ if the learner's answer is wrong.

After that, the teacher gave a group work, which would be solved in a group of three because the single classroom desk serves as a seat for three learners. Then, the teacher observes and encourages learners to solve the problem using the three techniques and says, ‘I will not let you out to break if the group does not solve the problem correctly’ within the time limit (ten minutes). Some groups finish and show their answer to the teacher, and the teacher lets them out for a break. Other groups could not solve it within the time limit. The teacher says, ‘‘I cannot wait for you more; please follow me step by step and try at your homes.’’ The teacher solves the problem using the three methods. Finally, the teacher revises all three methods and asks learners if they have a question; you are welcome; otherwise, this is all about today's topic.

Student 4: *It is un*clear *whether the graphical method helps solve equations with infinitely many solutions.*

Teacher P2: *The main concern is observing the graph's behaviour. If the first line overlaps over the second, it has infinitely many solutions, but this method does not tell us the relations between the two variables.*

In this classroom, there were no teaching aids (tools). The only resource is chalk and board; this private school has no plasma TV. Even though there are the usual TVs and LCD projectors in the school for teaching purposes, they were not used in the observed classroom. The teaching methods were teacher-centred and procedural; the teachers asked learners to remember the steps to solve simultaneous equations. Here, the teacher quality is the group discussion in that learners were not let out to their break if they did not solve the group discussion question. According to Koskinen and Pitkäniemi (2022), meaningful teaching engages learners in individual and collaborative activities. The researcher observes learners try their best to solve the question to use their break. Mistakes were tolerated in this class, especially during the last group activity. In a creativity-cultivating classroom, learners must be safe to make mistakes and engage in productive struggle (Liu et al., 2022). However, the teachers' feedback was not informative, as they responded by saying 'No' or 'Yes' to the learner's answers and not looking at how they solved the problem, which is essential for effective feedback.

Teacher N1's lesson observation

Name of school: School N (NGO School)

Subject: Mathematics

Class: 9A

Observed lesson topic:

Period: 1

Duration: 45 minutes

Date: 04Jan, 2022

Teacher N1: *Good morning, students* (the learners replied). *In the previous classes, we discussed solving quadratic equations using the method of factorization.* Who *can tell us the steps for using the factorization method when solving a quadratic equation?*

No one raises their hands.

Teacher N1: *Please read what you learned daily; otherwise, it will be difficult to remember.*

The teacher lists all four steps in using the method of factorization.

Teacher N1: *Today, we will see another method of solving quadratic equations: the completing the square method.*

The teacher describes all seven steps in completing the square methods and provides examples from the textbook. Following that, the teacher gives learners an exercise (class work). Learners raise their hands to show their answers to their teacher. After checking their answers, the teacher picks one learner among those who solved correctly to write the steps followed on the board. The learner came with his exercise book and solved it correctly as the teacher showed them. Unfortunately, one of the question's roots was $\sqrt{-1}$ learners doubt what they could do with this result.

Student 2: *I did not know what could be done with negative numbers in square roots.*

Teacher N1: *Good question; you have not yet learned about such numbers. Therefore, you need to conclude that the quadratic equation has no real number solution. You will understand what this solution means when you learn about complex numbers.*

After solving one additional example, the teacher asks if the learners have a question. The learners were only jotting down what their teacher wrote on the chalkboard. The teacher wanted to assess learners understanding by giving classwork from exercise 2.5 (p.94) of the textbook, but the time was gone, making it homework. The teacher concludes by asking learners if they have any questions.

This classroom has no teaching resources other than chalk and board. The teacher writes notes and solves problems on the blackboard, and learners take notes. The classroom follows the teacher-centred instruction method. The problems solved were repetitive and procedural, requiring learners to memorize the steps. However, repetition does not contribute to understanding (Williams, 2023). There were no group discussions observed here. The good quality the researcher observed in this teacher was that the teacher did not let out for latecomer learners. The teacher instead told them to tell their reason to their peers by standing in front of them. The learners feel ashamed to stand in front of their peers and tell their reasons, and the number of latecomers was few compared to the other observed classrooms. Two important outcomes of this approach are: first, learners did not miss their class; second, the teacher minimized latecomers systematically.

Teacher G1's lesson observation

Name of school: School G (Government school)

Subject: Mathematics

Class: 9D

Observed lesson topic: Solving systems of linear equations by graphical method

Period: 1

Duration: 45 minutes

Date: 30Nov, 2021

Teacher G1: *good morning, students***.** *In the previous class, you learned a system of linear equations in two variables and how to draw the two equations in a single graph. Today, we will see the graphical method of solving linear equations.*

Teacher G1*: who can tell me what we mean by a system of linear equations?*

(No one raises their hands.)

Teacher G1: *If you do not respond voluntarily, I will ask randomly by your numbers.* (There was silence again)

Student A raises his hands and tells *a set of two or more linear equations is called a system of linear equations.*

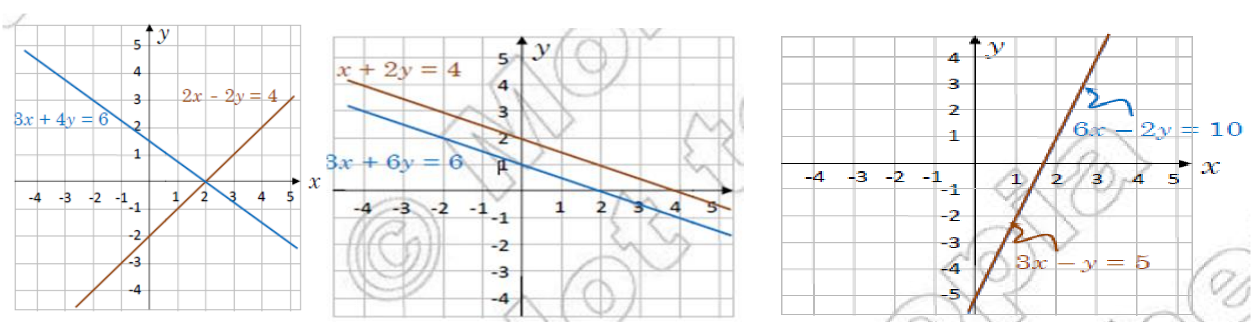
Teacher G1: *Excellent clap hands for him*

Teacher G1: *When you return to your homes daily, please read what you learned; otherwise, it will not be easy to remember. Okay, without wasting time, I will move to the next topic: take out your exercise book. Today, we will solve a system of linear equations using the graphical method. A system of linear equations in two variables may have a single solution, no solution, or infinitely many solutions.*

For example, draw the graph of *a)* $\begin{cases} 2x + 2y = 1 \\ x - 2y = 3 \end{cases}$ *b)* $\begin{cases} 3x - 2y = 2 \\ 9x - 6y = 5 \end{cases}$

c) $\begin{cases} x + y = 3 \\ 2x + 2y = 6 \end{cases}$

The teacher draws the graph of each of these three systems of linear equations and says to the learners that if the curves intersect at one point, the system has only one solution (see example a); if the curves are parallel, they have no solution (example b), and if the curves overlap they will have infinitely many solutions (check c). Now, *follow the plasma TV attentively.*



a) Unique solution b) no solution c) infinitely many solutions

Figure 4. 3: Graphical method of solving systems of linear equations (Adapted from grade nine students' textbook).

The teacher beams on the TV, taking 20 minutes to lecture learners. At this time, the role of the teacher was to follow the plasma instructions. When the TV asks questions, the teacher observes learners' work and encourages them to solve problems. After the plasma program ends, the teacher summarizes the topic and asks learners some questions from activity 2.6.

In this classroom, the stage was controlled by the teacher. The learner's role was mostly to answer the teacher's and plasma TV questions if possible. Otherwise, they listened and took notes from the blackboard. The classroom was not well-resourced. The only teaching tool is chalk and board, and the lecture on plasma TV gives learners a passive role. No collaborative learning was observed in this classroom. Collaborative work in mathematics classrooms motivates learners to share their ideas, argue, and reason out their problem-solving methods (Koskinen & Pitkäniemi, 2022). In addition, the teacher's questions were procedural, requiring rote memorization rather than assessing the learner's conceptual understanding.

Generally, the researcher observes that secondary school mathematics teachers apply teacher-centred instruction from the above section. Learners are expected to participate if the teacher asks them a question or if they have questions for the teacher; otherwise, they take notes and listen to the teacher's lesson. The overall observations have been discussed under personal quality, teaching approaches, and classroom management systems as follows.

a) Personal quality

Teachers want to help and know their learners' capacity well. The problem is the teacher's conception of helping their learners. They spent most of their time solving procedural, repetitive problems for their learners. They believe solving more repetitive problems helps learners internalize the procedure and recommend following the steps to solve exercises. Unfortunately, research studies show that repetition (Williams, 2023) and procedure without reasoning (Olsson & Granberg, 2022) does not help learners understand the subject.

The other observed behaviour of these three teachers was asking difficult questions for good achievers and fast learners and going with the pace of these learners. Unfortunately, this characteristic of teachers may harm slow and deep thinkers. These learners may think their teacher does not believe in their potential, so the teacher does not ask them difficult questions (Boaler, 2015) or wait until they finish their solution.

In addition, failure to answer teachers' questions is not considered a means to learning. During the lesson observation, teachers ask questions, learners respond with the final answer, and the teachers' feedback (by saying 'right' or 'wrong' to learners' final answer) is based on the final answer, not the reasoning behind learners thinking. The researcher thinks that mistakes are unavoidable in teaching and learning mathematics, and according to Brodie (2014), they are "easily corrected when pointed out" (p. 223). Additionally, teachers can use these as a means of learning by letting learners discuss; mistakes can promote debate among learners and be windows toward learners understanding (Zhuang & Conner, 2022). Therefore, teachers must consider that there is some reasoning behind learners' mistakes, work on learners' reasoning, and use them as a means of learning.

b) Pedagogical practices

All three teachers apply teacher-centred teaching methods. Teachers teach what is written in the textbook effectively and efficiently, and learners mostly listen and take notes. Teachers were good at executing calculations without making mistakes and rashly covering the lesson within the prescribed period, especially in government schools. The researcher believes learners can not understand the concept by repeating what is in the textbook rather than imitating it. Mathematics teachers should go beyond the textbook by providing additional examples and exercises. These tasks should not be repetitive but slightly different from what the textbook provides. In this ICT era, teachers can get many valid mathematical questions online by making little adjusting to their learners' context. A study by Machisi (2023) shows that secondary school learners were asked to evaluate their mathematics teachers' competency, and they criticize their teachers for relying heavily on textbooks to provide tasks and not being flexible in providing alternative problem-solving techniques.

c) Classroom ethos

The arrangements of the classrooms in these three schools were similar. Learners share a single-seat desk for three. Learners could not collaborate, and teachers could not apply round table discussion in these schools because the classroom size, arrangement of the desks, and the number of learners were not helpful for doing so. The classrooms did not have enough teaching resources besides chalk and board; teaching aids play a significant role in learners understanding (Ishartono et al., 2022). This scarcity affects learners' choice of learning; i.e., some learners may want to learn from computer simulation, while others through visualizing models, artefacts, and doing (such as measuring, using scissors and paper). Only the government school has plasma TV as a teaching aid, although its effectiveness is questionable.

III) Results from document analysis

Lesson plan

The lesson plans of teacher G2 have been analysed. The lesson plan contains the aims and objectives, teaching aids, methods, and learner activities of the daily lesson. Therefore, it has all the daily intended activity of the teacher in teaching mathematics. The researcher finds it essential to analyse it. The other one is the syllabus that is prepared at a national level, which contains the intentions of the textbook authors regarding what is needed to be achieved by the teachers using the prepared textbooks.

Table 4. 7: Weekly lesson plan format

<table>
<tr><th rowspan="2">Date</th><th rowspan="2">Section</th><th rowspan="2">Period</th><th rowspan="2">Content</th><th colspan="4">Teachers activity</th><th rowspan="2">Students activities</th><th rowspan="2">Teaching Aid</th><th rowspan="2">Teaching Method</th><th rowspan="2">Remark</th></tr>
<tr><th>Introduction</th><th>Presentation</th><th>Summary</th><th>Evaluation</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

The above table contains additional information such as the school's name, teacher name, subject, grade and section, unit, topic, and lesson objectives. The teacher is considered to work according to this format. It contains what unit, chapter, and topic to be covered, the objectives to be achieved, what teaching methods will be used, the teaching aids available, and what the role of learners will be.

The daily report is to be written in the remark section. Here, teachers are expected to report the learners' understanding of the lesson and teaching techniques. The remark is vital information to improve the course delivery for the following classes.

Table 4. 8: Teacher G1's lesson plan at School G

Weekly lesson plan format

Name of the School: G

Name of the Teachers: G1

Subject: maths

Grade & section: 9

Unit: Two

Topic: the system of linear equations

Objectives: At the end of the lesson, students will apply graphical method to solve the system of linear equations

Date	Section	period	content	Teachers activity				Students activities	Teaching Aid	Teaching Method	Remark
				Introduction	Presentation	Summary	Evaluation				
			System of linear equations by graphical method.	Introducing a system of linear equations by graphical method.	Giving a short note on the graphical method	Summarizing system of linear equations by graphical method	Giving Classwork exercise from activity 2.6	Taking notes, Listening attentively, active participation		Student center method	

The above table indicates the lesson plan prepared by teacher G1. This plan includes the lesson's title, objectives, teacher activity, learner activity, teaching aids, and instruction methods. The intended teaching method was learner-centred. The summary of the findings of the document analysis is seen below.

Table 4. 9: Summary of lesson plan analysis of school G and teacher G1

Descriptions	Yes	Partially	No
Lesson objectives consider connection-making.			✓
Lesson objectives look for learners' collaboration.		✓	
Lesson objectives help to engage learners in complex tasks.			✓
The lesson plan starts with a new topic by asking questions.			✓
The lesson plan connects chapters, subjects, and learners' real lives.			✓
Teaching aids and resources are helpful for teachers' and learners' choice of learning.			✓

National syllabus

The national syllabus is a framework for mathematics teachers' daily teaching activities. It includes teachers' competencies, content, time-allocated teaching, learning activities, teaching aids, and learner learning assessment. The tables below are from grade nine, the syllabus of the observed lessons.

Table 4. 10: National syllabus of grade nine, chapter two on the system of linear equation in two variables

Competencies	Contents	Teaching / Learning Activities and Resources	Assessment
• solve simultaneous	2.2 Systems of Linear equation into two	• With the active participation of the students revise how to find	• Give exercise problems on the

equation • identify the three cases of solutions of simultaneous equations (a unique solution, no solution, infinitely many solutions)	variables. (8 periods)	solution for a linear equation, i.e., equation like 2x + 3 = 7 and following this, a discussion with students how the solution of an equation of form 2x + 3y = 5 is determined. • Introducing the general form of a system of two linear equations with the help of examples. • Discuss the different methods of finding the solutions of the systems of two linear equations.' • Help students solve the system of simultaneous equations using elimination on substitutions or graphical methods.	application of each of the methods for solving system of linear equation

The above table is taken from a syllabus prepared at a national level to help teachers in their planning, teaching, and assessing of learners. The competencies learners should own after the lesson and resources helpful in teaching the topic are also included. Even the teacher should ask learners first how to solve a system of linear equations; the syllabus informs a teacher to revise and assist learners. This syllabus encourages learners' participation in solving simultaneous equations, which is good. The three methods of solving are provided, and then the learners are expected to memorize and apply the procedure to solve the equations. There is no connection between the chapters of the subject, between subjects, and the learner's real life, and no way for alternative techniques of solving the problem since it closes by saying there are three methods. Hence, teachers could not find the relevance of this topic. If there is no relevance, they cannot be the knowledge owners; if they are not the subject owners, they cannot control the classroom and cultivate creativity. The summary of its analysis is transcribed in the table below.

Table 4. 11: Summary of document analysis of syllabus on the system of linear equations in two variables

Descriptions	Yes	Partially	No
Syllabus objectives consider connection-making.			✓
Syllabus objectives look for learners' collaboration.		✓	
Syllabus objectives help to engage learners in complex tasks.			✓
The syllabus indicates that teachers should start a new topic by asking questions.			✓
The syllabus helps to make connections between chapters, subjects, and learners' real lives.			✓
Teaching aids and resources are helpful for teachers' and learners' choice of teaching and learning.			✓

The national syllabus and the lesson plan are the intentions of the curriculum and the teachers to be achieved in their classrooms. The lesson plan is prepared from the syllabus, which takes teachers' autonomy in their teaching and is not designed to support teachers for creative teaching skills. They encourage introducing a new topic with the help of examples instead of introducing problems. The learner-centred instruction method is encouraged, but not questioning stance and connection-making are mentioned to make an active classroom and easily engage learners in their learning.

IV) Post lesson Interview

Here, an interview was employed to collect data concerning teachers' challenges during their teaching. The interview data was presented, analysed, and discussed under the following subthemes: personal quality of teachers, pedagogical practice, and the classroom environment.

4.3.3 Challenges of Teaching Secondary School Mathematics

Learners fear mathematics and are not performing well in comparison to other subjects. From the teacher observation section, the teachers are not presenting the subject relevantly since they dictate what is written in the textbook without any adjustment. Here, the researcher asks teachers to justify why learners fail to grasp the concept of mathematics and perform well.

Results from teacher interview

Researcher: Why do you think learners fear and fail in mathematics more than other subjects?

Teacher G1: *The time is short to address all students. We go with the pace of a few fast learners. I feel as if most of the student's learning is ignored.*

Teacher G2*:* *The first thing is the perception they come to school with, starting from early childhood. Students come to school thinking that mathematics is a complicated subject that a few gifted students can achieve. Therefore, they are not working hard; instead, they put it aside. In addition, parents focus more on their child's mathematics results than other subjects, which may also lead learners to frustration if they fail, which is expected. The other one is the authoritarian behaviour of some teachers; they demoralize their students, unlike teachers of other subjects.*

Teacher P1: *We are teaching mathematics of scholars, not the actual mathematics practised in the learners' society. Hence, learners do not think every mathematical concept comes to solve real problems but as an abstract subject without any relevance to their lives.*

Teacher P2: *The class size is large on average, with 55 students in a single class; teachers cannot use collaborative instruction methods that could address all the learners. In handling this class size, teachers go with the pace of fast learners, and the other students are ignored.*

Teacher N1: *The teaching method we use is not supportive. Students are made to believe that in mathematics, there is only one right way to be followed to get the single correct answer. There is no negotiation in maths as in other subjects such as civics; students can debate, negotiate, justify, and share their views.*

Teacher N2: *Technologically incompetent teachers doubled with a lack of teaching aids in the classrooms, contributing to learners' learning deficiency.*

a) Classroom Ethos

Class size

The class size of each classroom is, on average, 55 learners. It is a large class to manage and teach learners effectively (apply differentiated instruction method). Such an environment forces teachers to apply teacher-centred teaching methods and reduces the effectiveness of teachers (Buchel, Jakob, Kühnhanss, Steffen, & Brunetti, 2022). The teacher dictates, and learners hear and write notes. Learners do not get the chance to guess, defend, and justify their ideas, and large class sizes deny learners collaboration. Most learners' reasoning behind their work is ignored here. Hence, spontaneously, misconception may be created on the side of learners in that their primary duty in the classroom is to hear and jot down notes, not to challenge teachers and justify their ideas. Therefore, learners fail to grasp the concept and acquire procedural and shallow knowledge.

Shortage of time

Especially in most government schools, teachers have only 25 minutes to teach out of the total 45 minutes allocated. The other 20 minutes are allocated for plasma TVs even though not all government schools have them. Therefore, teachers rush to cover their topic within the prescribed period without considering their learner’s learning. Consequently, teachers go with the pace of fast learners by ignoring most of the classroom. As a result, most learners believe their teacher does not believe in their competence and hence does not exert more effort in mathematics (Boaler, 2015).

Lack of resources

The classrooms are not well-resourced with supportive technologies. Teaching technologies help to visualise problems and save time in understanding and solving them. A study conducted by Attard and Holmes (2022) concluded that using technology in teaching provides differentiation and personalised learning approaches, visualisation and dynamic manipulation of mathematics concepts, and alternative methods for teacher-learner feedback and communication. The observed classrooms do not support teachers with experience in using teaching technologies. There is no other choice of teaching other than chalk and board. This trend impacts teachers' teaching skills to visualize and understand problems clearly.

Learners' Perceptions and parents' expectation

Learners come to school with failed ideas regarding mathematics. At their early stage of learning, their seniors told them mathematics is a subject only for the gifted ones. They consider mathematics the most challenging subject, only understood by a few learners, and they fail to struggle with it. However, a study by Hagan, Amoaddai, Lawer, and Atteh (2020) indicates no relation between learners' perceptions and academic achievement. The researcher does not agree with this idea because learners' failure ideas negatively impact their self-efficacy. Self-efficacy helps learners engage in their learning, which is the predictor of success (Tomas, Gutiérrez, Georgieva, & Hernández, 2020). In addition, their parent's focus is on mathematics; they measure their children's success in their children's achievement in mathematics. Society perceives mathematics as the foundation for scientific and technological knowledge that societies cherish (Hagan et al., 2020). Therefore, learners feel more anxious about mathematics than other subjects.

b) Pedagogy

Mathematics of scholars

The tasks in the textbook are not linked to teachers' and learners' experiences. Almost all of the mathematics content and tasks in the textbooks are not presented relevantly. The textbooks also influence teachers' teaching methods. The observed teachers do not make connections between mathematics concepts, real life, and other subjects. Learners struggle to grasp concepts as they fail to connect to their lives; this frustrates learners and makes them think of mathematics as an abstract subject discovered by mathematicians that is irrelevant to their lives (Gebremichael, 2019).

Poor instruction method

The teaching techniques mathematics teachers follow are not good for learners' deep understanding. Most of the time, the teaching technique is teacher-centred in schools. Unlike in other subjects, such as civics, there is no discussion or negotiation, and learners are encouraged to defend their views. The most common trend in the mathematics classroom is that the teacher shows the procedure to solve a problem and recommends that learners follow that step to reach the single correct answer. Teacher-centred teaching is modular, linear, highly directed, controlled, and program-centred (Luke et al., 2021). This trend makes learners think of mathematics as a closed subject with predetermined equations to be followed and has no way for creativity and divergent thinking.

Technological incompetency of teachers

In the third millennium, the ICT revolution comes with many teaching aids to make learning easier for learners. There are a lot of software that are helpful for visualizing and solving mathematical problems, for instance, Geogebra or Win Plot. This software helps to make mathematical concepts clear in a short time. Such technologies are supportive of large class sizes and limited time. Therefore, teachers must be competent in teaching technologies (Beswick & Fraser, 2019). Teachers' competencies in these teaching technologies help learners understand the concept easily.

c) Personal characteristics of teachers

Believing in fast learners

Learners prioritize learning and thus work for teachers they care about and perceive as also valuing their learning (Dahal, Luitel, & Pant, 2019). Teachers trust good achievers and have positive relations with them. They give them more rights to ask and answer questions than lower achievers. Even in correcting exam papers, there are biases because of the teachers' preconception that fast learners will achieve the best. This behaviour of teachers has a loud message for slow and deep thinkers and low achievers. Even though the teachers do not say a single word verbally that they do not believe in the potential of slow learners, they still tell them practically. For instance, mathematics teachers did not ask these learners challenging questions because teachers did not think they had the potential to solve them. Slow learners perceive that their teachers do not value them. An interventional study by Korikana (2020) indicates that slow learners were more successful when suitable conditions and educational opportunities were provided. According to Korikana (2020), his study applied an inspiring quote from the universal scientist Albert Einstein: "I never teach my pupils. I only attempt to provide the conditions in which they can learn" and found it supportive.

Appreciating results, not efforts

The importance of praise for efforts was confirmed in an experimental study by Stanford psychologists Carol Dweck and Mueller (1998). Half of the learners involved in a math test were praised as 'smart' for their scores; the other half were praised for their effort. After that, Dweck and Mueller (1998) asked learners if they would like to take a test at an easy or slightly challenging level. Those who had been praised for effort accepted the challenging one. However, 90% of those praised as 'smart' for their scores chose to take the easy test; they did not want to take the risk. Dweck and Mueller concluded that teachers unintentionally fetter the learner's risk-taking by heaping praise on achievement.

Studies conducted by (Dweck, 2006; Boaler, 2015) show that when learners get work incorrect, they recommend not saying, "That is wrong," instead, teachers need to look at their thinking and work with it. There is always some logic in learners' thinking, and it is good to find it so that teachers avoid the "failure" idea and honour learners' thinking. In the observation session, the teacher's concern was the last answer, not why, in problem-solving procedures. The teacher's feedback was also by responding to learners' answers by saying ‘right’ or ‘wrong.’ It is difficult to think about the feelings of learners who proceed through the correct methods (steps) and lose the final answer by mistake in such an environment.

Authoritarian teacher’s behaviour

Teachers' offensiveness was characterized by strictness, unreasonable reactions, and arbitrary decisions such as refusing late work, punishing the whole class for one learner's wrongdoing, and looking rigid, inflexible, and with an authoritarian personality (Ukobizaba, Ndihokubwayo, & Uworwabayeho, 2020). In some teachers' classrooms, the ideas raised by learners are not valued. The teacher acts like they are at the higher level of the power structure in the classroom. Learners fear raising their opinions as the teacher uses aggressive words in responding to learners’ ideas. It is essential that learners engage in proposing ideas or, to use the mathematical term, making conjectures about mathematics. The creativity-cultivating classroom environment also needs to be safe for making mistakes, but in front of these teachers, making mistakes is forbidden and unacceptable. The learners should raise their hands to answer when they have the correct answer. There is no possibility of thinking in these teachers' classrooms. This environment makes learners fear sharing their ideas and opinions and debate the validity of approaches and solutions.

4.3.4 Discussion of Research Question Three

Research question three aimed to explore mathematics teachers’ perceptions and experiences of creative teaching. The concern of this question was to ensure to what extent mathematics teachers apply connection-making, control the classroom in response to learners’ activity, own the knowledge they teach, use innovative teaching strategies, and value learners’ unusual ideas. Wood’s four features of creative teaching and Cremin’s dimension of creative practice were used as lenses to develop this question. The respondent’s interview results indicate that teachers practice creative teaching strategies to some extent.

The researcher tries to unfold the teachers’ conception of creative teaching. Teachers’ understanding of the concept of creative teaching is good. They respond to creative teaching as concept teaching (teacher G1), which focuses on the aims and objectives of the topic (teacher N1), which could be transferred to new problems (teacher G2) rather than specific calculations. Therefore, theoretically, teachers have a good view of creative teaching. The problem is in practising it in real classrooms.

The second phase in searching for a response to the third question was through observation. Observation helps to understand and get what is going on in the classroom. The researcher observes the teaching of three secondary school teachers, and there is a contradiction between the interview and observation. Teachers have difficulty putting into practice what they say. The teacher observation session confirms this deficiency. In the observation session, teachers introduce the lesson and define the topic by providing formulas and solving problems using these procedures without reasoning (Hurrell, 2021). The researcher did not observe teachers who started the new lesson by asking questions, opening closed problems, connecting the school mathematics to the learner's experience, or showing alternative problem-solving techniques, which contradicted the response from teachers in the interview session. They rashly cover the lesson and provide procedural exercises written in the textbooks without any adjustment. Teaching is a scientific process; its major components are content, communication, and feedback. Teaching strategy positively affects learner learning; modifying, improving, and developing the strategy is always possible (Rajagopalan, 2019). The concern of this research question was how to communicate with learners in presenting the content and giving feedback creatively.

Document analysis was also conducted to answer research question three. The documents prepared by teachers and at a national level were analysed. The lesson plan for the system of linear equations prepared by teacher G1 and the national syllabus on the same topic were unsupportive of creative teaching. Both encourage learner-centred teaching but do not provide practicable techniques.

Some sources of fear in mathematics among learners are being too quick in mathematics classroom lessons, giving too many notes, exercises, punishments, and embarrassing/alarming statements (Ismail, Garba, Osman, Ibrahim, & Bunyamin, 2022). In this study, the last one on exploring teachers' practice was about the challenges that make learners fear and fail in mathematics. The teachers’ response to the question was reasonable. The class size, time allocated, especially in the government schools with plasma TVs, learners’ failure preconceptions, parents’ expectations, shortage of resources, teachers’ misconduct, and teachers’ incompetency in educational technology were listed.

4.3.5 Summary of Research Question Three

The research finding above showed that teachers were not practising creative, unusual, and challenging teaching methods. They teach what is written in the textbooks, including its deficiencies, without any adjustment. The lesson plan prepared by individual teachers also reflects the traditional teaching method. Learners could not get mathematics’ relevance through such teaching methods. That is why learners fear and fail in mathematics more than other subjects.

Creative teachers care about their learners’ emotional well-being in the classroom. Teachers’ emotions are contagious; hence, they must care about what they are doing during their teaching, asking questions and giving feedback to learners (Frenzel, Becker-Kurz, Pekrun, Goetz, & Lüdtke, 2018). Creativity is cultivated if learners feel free to interact, guess, and make mistakes. The other teachers’ issue concerns the resource; in the 21st-century classroom, a technologically well-equipped classroom helps learners visualize problems, make simulations, and quickly understand the concept under investigation.

Creative teachers are curious to help their learners and create a conducive environment that respects and stimulates learning (Apak, Taat & Suki, 2021). These teachers have confidence in their work and are not concerned with the expectations of others. They use their imagination to connect school mathematics and learners’ real lives, among other subjects and within the subjects.

4.4 Research Question 4

What is the role of the existing CPD in equipping mathematics teachers with the skill of creative teaching?

This section unpacks the experience of mathematics teachers' professional development. The impact of continuous professional development on teachers' skill of creative teaching and the challenges teachers face in implementing the acquired skill in the classroom were explored. Data was collected through one-on-one interviews and document analysis of CPD materials. This research question was discussed under Wood's features of creative teaching relevance, control, ownership, and innovation and Cremin's dimensions of creative teaching, including pedagogy, classroom ethos, and personal quality.

I) Interview

4.4.1 Relevance

Connection-making helps teachers and learners find the subject's relevance to their lives. Relevance helps teachers own the knowledge they teach and use it flexibly in new contexts, leading to innovative teaching. Therefore, the starting point of creative teaching is the relevance of the content and tasks. Teachers need to find the relevance of their teaching subjects to their lives. As discussed before, secondary school mathematics textbook content and tasks were presented irrelevantly, as no connection was observed. In such a reality, the role of CPD should be to fill the gap between textbooks and real-life mathematics. The teachers' responses concerning this issue were as follows.

Researcher: What was the role of CPD you took in connection-making between school and real-life mathematics?

Teacher G1*:* *How to teach efficiently and effectively what is written in the textbook is the focus of the CPD, not connection-making.*

Teacher G2: *The CPD training focused more on developing learners' active participation. Even though students become active participants (engaged in learning quickly) only when the topic is familiar/connected to their lives, this issue is missed in the CPD.*

Teacher P1: *Not more than how to use models in teaching geometry.*

Teacher P2: *Using models in teaching geometry.*

Teacher N1: *The CPD focused on active learning and making an effective continuous assessment, not on connection-making.*

Teacher N2: *It is not helpful in connection-making; its focus is on the active participation of learners but in the wrong method since, without relevance, there would not be true active participation of learners.*

Teachers from the private school responded that the CPD helped to teach geometry using models. Teacher G1 from the government school responds that the primary issue of the CPD training was how to teach 'effectively and efficiently what is written in the textbook.' From teacher G1's response, the CPD aimed to help teachers teach the dictation of the textbook without making any connection to their lives. The other three teachers' responses provide more explanation to justify their responses; the CPD training emphasis was on active learning. The teachers believe that the classroom becomes active only when learners are engaged easily in their learning and when they find school mathematics relevant. Therefore, from the teachers' response, the CPD program they took did not support the connection-making between school and real-life mathematics.

The researcher believes that the CPD should train teachers on practicable concepts. Training what is written in the textbook only, as said by teacher G1, could not change teachers' competence in connection-making. Active learning, where learners construct their learning independently, is urgently needed for 21st-century schooling. However, learners are engaged in their learning simply if they are familiar with the concept, as they cannot construct their learning in a vacuum context. Therefore, the CPD should help teachers connect school and out-of-school mathematics, between chapters of the subject, and with other subjects. Teachers and learners must view mathematics as an integrated whole rather than a collection of unrelated topics

(Winter, 2022). The connection made by the CPD must be concrete, not theoretical. A study by Weinhandl, Lavicza, Houghton, and Hohenwarter (2022) indicates that learners found it simpler to draw connections when given actual challenges and assignments.

4.4.2 Control

As evaluated above, all textbook tasks are closed; this does not open the door to creativity. Learners need to follow different techniques and reach different correct answers. Unfortunately, from the previous interview, teachers' responses show they teach what is written in the text. The role of the CPD here is clear; it must show teachers how to open up closed problems. Teachers were asked about this, and their responses were as follows.

Researcher: How helpful was the CPD you took to open up closed problems?

Teacher G1: It *was not supportive; it was more on general issues such as active learning, not specific techniques.*

Teacher G2: *Not helpful; most of the training was not directly related to my classroom activities.*

Teacher P1: *Action research and learner-centred instruction methods, which were not based on specific techniques, were the biggest concerns of the CPD training.*

Teacher P2: *The CPD is not dealing with such practicable activities.*

Teacher N1: *Open problems help teachers and learners to make the classroom more active, but the CPD does not consider such practicable experiences.*

Teacher N2: *It was not supportive; the focus of CPD that I took was on how to conduct a continuous assessment and general techniques such as learner-centred teaching methods.*

The teachers responded that their CPD training was 'not dealing with such practicable activities' (P2, N1). The training is not directly related to classroom activities (G2); they are theoretical. They focus more on general issues such as conducting action research, active learning, and continuous assessment (G1, P1, & N2). The teachers believe that their CPD training did not help them to open up closed problems.

Opening up closed problems helps learners come up with different solution paths and encourages differentiated learning. It also generates infinite possible answers (Suherman & Vidakovich, 2022). In making the classroom more participatory, active, or simply learner-centred, tasks need to be solved through different techniques and come up with multiple correct answers. This technique helps learners propose ideas, defend their approaches, and debate with their colleagues, hence creativity.

All problems are not expected to be open; some questions are reasonably closed and have a single correct answer. In facing such kinds of tasks, alternative techniques for solving tasks lead to creativity. The researcher asked teachers if the CPD helped them to do so, and their responses were discussed under the theme of innovation.

4.4.3 Innovation

From previous results, teachers show their learners alternative techniques for solving single mathematical questions written in the textbook. The teachers did not go beyond what was in the textbook. The researcher asked teachers if the CPD program was supportive in providing more alternative techniques for solving single tasks.

Researcher: What was the role of CPD in providing alternative techniques for solving a single problem?

Teacher G1*:* *Not more than what is written in the textbooks in showing alternative techniques aiming to create active student participation, not for the sake of alternative techniques and creativity.*

Teacher G2: *The CPD rarely provides alternative tools, not alternative techniques.*

Teacher P1: *Not other than quadratic equations, also written in the textbooks.*

Teacher P2: *When higher institutions gave CPD training, the focus was on integrating technology into teaching and solving problems. However, this could not be considered an alternative technique but a tool. Therefore, the CPD did not help equip teachers with an alternative problem-solving technique.*

Teacher N1: *There are technologies used to help solve problems, but they are not applicable due to school resource scarcity.*

Teacher N2: *It was not supportive for teachers by providing alternative methods.*

Teachers' repose to this question was identical; all they spoke was 'nothing.' The attempt by trainers was made only those written in the textbooks (G1), such as quadratic equations (P1). Instead, some training given by higher institutions comes with alternative tools for problem-solving and concept understanding (G1, P2 & N1). Unfortunately, alternative tools cannot replace alternative techniques. Therefore, the CPD program does not pave the way for innovation by providing alternative problem-solving techniques.

Showing alternative problem-solving techniques during CPD training improves teachers' sense-making and motivates them to search for other optimal solution methods instead of following what is in the textbook. According to Simamora and Saragih (2019), the approach is called guided discovery and improves learners' problem-solving skills and creativity. To this end, teachers must have this competency first through CPD. This behaviour of teachers is contagious and reflects in their learners; learners as mathematicians develop the skill of seeing all possibilities in solving mathematical problems and their life activities. Creating genuine problem solvers is the end goal of creative teaching.

4.4.4 Ownership

Teachers are not knowledge-transmitting machines; like they teach (dictate) what the authors write in the textbooks, they must own the knowledge they teach. From the textbook analysis result, some unrealistic problems need adjustment in the text. In addition, the teachers' interview results reveal that they also teach what is written in the textbook. Therefore, the CPD training program should consider this issue. The researcher asks teachers if there is a contribution of the CPD they took in adjusting unrealistic problems or pseudo-context tasks.

Researcher: What was the role of CPD in adjusting some unrealistic problems in the textbooks?

Teacher G1*: Not helpful in adjusting tasks; it was theoretical, not practical in supporting teaching.*

Teacher G2: *The CPD's effort was on effectively teaching what is written in the textbook and assessing learners effectively, not adjusting task deficiencies.*

Teacher P1: *Nothing*

Teacher P2: *Not helpful; it was not this deep in helping teachers.*

Teacher N1: *It is not suitable for improving instruction and tasks that teachers face daily. It is more for report writing.*

Teacher N2: *Nothing*

According to the teacher's response, the CPD did not adjust any unrealistic task written in the textbooks. The CPD was not that deep in supporting teachers (P2). It was not planned and designed honestly to help teachers. Teachers believe that the CPD training they took is for the sake of report writing (N1) for the school directors. As a result, the teachers teach what is written in the textbook; this leads the learners to perceive mathematics as far from reality as some mathematical tasks, as described before in the document analysis, need adjustment. "Students can neglect realistic considerations if the word problem is unrealistic'' (Carotenuto, Martino, & Lemmi, 2021, p.820). Therefore, one task of the CPD must be to adjust to unrealistic problems.

4.4.5 Pedagogy

The primary objective of CPD is to help teachers with teaching skills, which should come with improvement in learners learning. Therefore, teachers need to get practicable knowledge during the CPD program.

Researcher*: How do you see the practicability of the CPD you took in teaching mathematics?*

Teacher G1: *It is more in action research, not in actual classroom improvements.*

Teacher G2: *Little, the CPD program's purpose is for report writing, not to improve teaching. For instance, most of the training encourages student cantered instruction methods but does not consider the number of students in a single classroom, the arrangement of the classroom, and the time allocated.*

Teacher P1: *CPD is good for improving the quality of education, but in my experience, I did not see it.*

Teacher P2: *A few training sessions were suitable for performing my day-to-day activities.*

Teacher N1: *Though CPD training has its limitations, it helps me to use teaching aids (technology) and classroom management; most of the content in the CPD was not practicable. The problem is that the school did not have resources.*

Teacher N2: *It is perfect for our day-to-day teaching activity, but no resource exists.*

From the results of the above interviews, all the teachers doubted the practicability of the CPD they took. Teacher G1 from the government school complains that the training of CPD is more on how to do action research, not on improving real classroom teaching shortcomings. Teacher G2 from a government school explains (a professional teacher) more clearly that the CPD program they took seems to report writing: we have done this and this and the like. It did not consider the reality of the school class size, arrangement, and time assigned for each period.

Teacher P1 from a private school praises the importance of CPD, but he is not satisfied with what he experienced. According to this teacher, the CPD was irrelevant in improving teaching in the classroom. Teacher P2 from the same school said there are a few helpful pieces of training but fails to describe in which dimension. Therefore, the teachers in the private school are not satisfied with the CPD they took.

When we came to the NGO School, teacher N1 explained that the CPD training was good, but there were no resources in the school to implement it. Teacher N1 agrees that the CPD he took was not practicable, but it is not because of the training; the problem is that there are no resources on the side of the school. Similarly, teacher N2 in the same school has a similar view in that there are no resources in the schools to put into practice what was trained.

For a CPD designed to enhance teachers' creative teaching skills, how that teaching skill is estimated to be transformed into the classroom to increase learners' learning must be detailed. The clear connecting of concepts or activities educated in the CPD to the textbook, lessons, indigenous knowledge, and other material the teachers are using in the classroom has been confirmed in various cases to be a powerful and conceivably essential section of the puzzle (Santagata & Lee, 2019).

4.4.6 Classroom ethos

Teachers were asked to explain the challenges they experienced in implementing the skills they acquired during CPD training in their classrooms. Identifying obstacles helps CPD trainers and school administration to consider and solve these issues. Teachers' responses are presented below.

Researcher: ***What challenges do you experience in implementing the skills you get during the CPD program?***

Teacher G1: *Lack of materials and shortage of time. When I started implementing the skill I got in CPD, I faced a lack of time (45 minutes), materials, classroom size, and the number of students.*

Teacher G2: *Shortage of time and materials and lack of interest from the team members. Some CPD trainers train us to sketch curves using mathematics applications such as Win Plot. Unfortunately, it is not practicable in our teaching because our school has no technological resources to apply it.*

Teacher P1: *Shortage of materials*

Teacher P2: *CPD is not designed to make math teachers creative and hence is not motivating; time constraints and load are some of the challenges.*

Teacher N1: *Lack of time and resources.*

Teacher N2: *Shortage of time, lack of materials, and classroom size are the challenges*

According to teacher P2, the CPD he took is not designed to help teachers teach creatively. The response of teachers to the above question is more or less similar. The challenges they face to implement the skills they got during the CPD program are time, lack of teaching aid materials (especially technology, computers, LCD), large class size, which is challenging to manage for active learning, and lack of interest in some of the CPD team members are the main challenges. In the researcher's view, experts should consider the reality of each school's ethos. Imposing CPD without considering the school setting could not effectively change teachers' practice positively. The CPD activities must provide realistic learning experiences, enabling teachers to contextualize and implement new knowledge in real classroom situations (Abakah, 2023).

4.4.7 Personal quality

i) Ideal CPD

Teachers were also asked to describe the CPD they need or imagine as supportive. This research question helps to identify the teacher's needs and act accordingly. Their response was as seen below.

Researcher: ***Would you describe what you think the ideal CPD program for creative teaching should be?***

Teacher G1: *It should focus more on self-assessment, self-ethics, and creativity in the subject matter.*

Teacher G2: *The CPD must be practicable in the actual classroom, not theoretical. Active learning and training on teaching software were the concerns of most of the CPDs I took, but it does not consider the school's class size and resources and fails to meet its objective. The CPD must be designed for large class sizes and concrete teaching techniques.*

Teacher P1: It must focus on *self-assessment, professional ethics, and the quality of a good counsellor.*

Teacher P2: *Must consider self-evaluation, self-assessment, and counselling activity.*

Teacher N1: *It should help teachers towards relevant teaching.*

Teacher N2: *Using actual research in and outside the school compound, use it as an input for CPD.*

According to teacher G1 from a government school, the CPD should help teachers with self-assessment and self-evaluation abilities and acquire creative teaching skills. Through self-evaluation, teachers evaluate their work and improve their deficiencies continuously. Whereas teacher G2's view was that the practicability of the CPD is crucial unless it fails to achieve its objectives. Hence, CPD needs to consider the class size and resources in the school and design it accordingly, especially in teaching techniques.

Teachers P1 and P2 from the private school speak that the concern of the CPD needs to be on enabling teachers to self-evaluate in line with teacher G1's ideas in the government school. Self-evaluation is essential as the teacher continuously improves from their previous teaching experiences. Teachers from the NGO school teacher N1 say the CPD concern should be helping teachers with relevant teaching techniques. Teacher N2 responds that research should be conducted within and outside schools, and teachers should be trained based on the results. In essence, teacher N2's idea is in line with teacher N1's idea in that both teachers consider CPD's concern to be to help teachers with relevant teaching skills. CPD becomes effective only if those structured learning activities result in changes to teachers' knowledge, classroom practices, and improvement in student learning (Abakah, 2023).

In the researcher's view, CPD should also consider the impact of Artificial intelligence (AI). What is the role of teachers that machine teachers could not replace? In this era, AI machines can answer mathematics questions by analysing millions of recent studies (it needs good internet only); in a short time, human teachers could not do this. Teachers face challenges that did not exist before; to survive as a 21st-century influential teacher, being a creative teacher is the only way machines cannot do. At least today, these machines are not responsive to learners' situations and emotions and lack mental flexibility; no one can exactly predict what will happen in the future. Therefore, the CPD needs to make clear the task distribution between these machines and human mathematics teachers in addition to what the respondent teachers said.

ii) Integration of indigenous mathematics knowledge

The textbooks' content and tasks were not rooted in the teacher's or learners' society or culture. Both teachers and learners miss its relevance to their lives, as described before. Therefore, there is a need to weave the gap between school and out-of-school mathematics through CPD. Teachers were asked how it could be done, and their answers were transcribed below.

Researcher: ***How do you recommend integrating indigenous mathematics knowledge or the real-life context of mathematics into CPD?***

Teacher G1: *Working with CPD experts and teachers together as a team.*

Teacher G2: *Sharing experiences among students about their daily mathematics life activities is supportive. This experience sharing includes giving a project to collect mathematics experiences* *of their society, whether in the market, agriculture, or myths. Then, a discussion session between mathematics teachers and CPD experts should be organised to provide a meaningful experience.*

Teacher P1: *Working with CPD professionals and mathematics teachers together as a team in including indigenous mathematics knowledge in the CPD*

Teacher P2: *The teachers may ask students to come up with mathematics practised in their society, and then sharing these with CPD experts can be helpful.*

Teacher N1: *Professionals should research society to uncover indigenous mathematics knowledge and then train teachers in school.*

Teacher N2: *Our society uses its budget and time by program; CPD experts may include these experiences of society into their training.*

From the interview result, teacher G1 recommends that there should be a collaboration between teachers and CPD experts in integrating indigenous mathematics knowledge into school mathematics during training teachers in the CPD program. Teacher G2 from the same school responds that the responsibility should be shared with learners, too. The teacher should ask learners to collect indigenous mathematics knowledge and share their findings among learners in the classroom. Afterwards, the teachers may collaborate with CPD experts to integrate these experiences into CPD. The interview result indicates that teachers should be owners of the CPD they trained. Studies show that externally imposed CPD will not align with teachers' desires and usually does not achieve its goals (Smith, Julie, Nel, & Gierdien, 2022).

Teacher P1 from the private school idea aligns with Teacher G1's, and Teacher P2's response was similar to Teacher G2's. Teachers P1 and G1 did not take pedagogy courses during their learning. Unlike these teachers, G2 and P2 are professional teachers; the response difference may result from their exposure. The responses of the latter two teachers were more powerful than those of the first two teachers, who did not train in pedagogy courses. The response of teachers from the NGO School was similar. Both teachers recommend that CPD experts research indigenous mathematics knowledge of their society, and following that, they must integrate into the CPD program and then train teachers.

II) Document analysis

The researcher tries to analyse CPD materials developed at the national and school level. Unfortunately, the schools do not have subject-specific documented CPD materials. The mathematics department is considered as one CPD group and prepares CPD training every two weeks. However, the researcher observed no documentation of CPD materials in the sample schools. Nothing could be said about the expected CPD materials developed at the school level.

Two CPD documents were developed to help elementary and secondary school teachers throughout Ethiopia. These are the CPD framework (MoE, 2009a) and the CPD toolkit (MoE, 2009b). They are general directions to schools, teachers, and supervisors. The most responsibility of the CPD is laid on teachers. For instance, the CPD framework states that ‘‘…teachers need to plan and carry out their Continuous Professional Development systematically’’ (MoE, 2009a, p.13). Its next page says, ‘‘All Ethiopian schools need to produce their school improvement plans, and CPD is the essential part of school improvement’’ (p.14). Unfortunately, as described above, the schools do not have self-developed, documented, and subject-specific CPD documents.

National Program for Strengthening Mathematics and Science Education in Ethiopia (SMASEE) has developed a subject-specific CPD material named mathematics as ‘‘book 2’’. However, this material is functional only for elementary schools. There is no such kind of material developed for secondary school, which would be good to appreciate its strengths or criticize its deficiencies. The CPD framework and toolkit seem to be ‘one size fits all’ types of documents; they did not differentiate between mathematics and history or consider the difference between schools' resources, location, and human resources.

4.4.9 Discussion of research question four

The data presentation and analysis show to what extent the CPD experience of teachers was practicable and helpful in their teaching practice, its shortcomings, and teachers' recommendations. The research concerns mathematics, a long (connected) subject with many rules, formulas, and methods.

In mathematics, it is difficult to grasp all the rules; therefore, the content of CPD needs to be more on concepts to get internalized in the less competent teachers. One means of conceptualization is connecting mathematical ideas among subjects and real-life activities. From the teachers' interview results, the concern of the CPD they took was not on connection making but more on learner-centred instruction (teachers G2, N1 & N2). To make the classroom more learner-centred, learners must be familiar with the content, which could be made through connection-making only.

From the teachers' responses, they were not satisfied with the practicability of the CPD that they took. It is more on conducting action research and active learning (G1, P1 & N2) than in actual classroom practices. Learner-centred teaching is the most common training in the CPD but is not practicable; it is not presented systematically in the way it could be adapted to real classrooms. Teachers prefer to engage in CPD activities closely linked to classroom practice (Smith et al., 2022). According to teacher G2's response, school training seems to be for report writing for the school's governors. Professional development has to be fundamentally linked in sustained and intentional ways to everyday classroom teaching and learning activities. Professional development content and tasks should be tied with the instructional practices (i.e., activities). As a result, the concepts and tools encountered in the inter-mental plane may truly get internalized and have a lasting effect on teachers' classroom practices.

The challenges teachers face in CPD were also explored. Some teachers lack interest in participating in the CPD program and changing their teaching routines (G2). In the beginning, teachers' expectations were high from the professional development training. However, when they observe that the CPD is irrelevant to their teaching, they consider it a waste of time. These teachers perceive the CPD's purpose as for report writing, not for real teacher change. Every social interaction during the CPD program does not drive teachers' development for creative teaching; only relevant CPD programs to the teachers embedded in purposeful activities directed at achieving planned goals will drive the required development. The researcher thinks effective training designed with the direct participation of teachers could alleviate the challenge before the training; teachers also list some challenges following the training.

The most common challenges from the teachers' interview responses were the lack of resources in their schools, large class sizes, and limited spaces (G2 & N1). The respondents said training in using technologies given by higher institutions was good, but the schools do not have such resources and hence are not applicable. The other challenge is the class size; for instance, the number of learners and the classroom arrangement must support applying a learner-centred teaching method. For a classroom of, on average, 55 learners who share one seating desk for three learners, teachers' stress increases (Saloviita & Pakarinen, 2021). Therefore, the CPD needs to adjust its concern on how to deal with such kinds of classrooms and resources.

Teachers also comment on what they think is the ideal CPD. Teachers need CPD to equip them with mental flexibility that helps them continuously reinvent themselves with the world's developments in mathematics. School-level creativity is expressed by mental flexibility in solving problems using different techniques (Klein & Leikin, 2020). CPD should help teachers to have the skill to continuously evaluate their teaching methods and learners' learning and improve their deficiencies. Current teachers are the product of traditional teaching and learning methods and lack mental flexibility. Therefore, they need to change their perception and practice in mathematics and teaching mathematics. The end goal of CPD for creative teaching is to equip teachers with the capacity for self-direction.

Mathematics is a cultural phenomenon, a set of ideas, connections, and relationships that we can use to make sense of the world. The content and tasks of CPD may derived by integrating textbooks and society's mathematics knowledge. Mathematics is commonly taught using formal methods that are disconnected from the sociocultural realities of society and are based on normative and dogmatic concepts (Hendriyanto et al., 2023). Due to the fact that learners' understanding of mathematics is limited, they feel that learning mathematics has no purpose and cannot apply their knowledge to solve real-world problems. Mathematics learning needs to start by using the context of socio-cultural and the reality around learners. Teachers are the most important variable to impact learners' learning sustainably over time deeply. Professional development experts could get this by collecting information from their society, learners, and teachers because mathematics was discovered to solve society's problems.

The CPD materials for secondary school are prepared only at a national level. The document prepared at a national level is general and does not differentiate between mathematics and history. Even the CPD framework puts the schools responsible for preparing their CPD materials; they have not documented subject-specific CPD materials. Putting more responsibility on the education bureaus, schools, and teachers confuses teachers concerning the ownership of the CPD. CPDs are provided by different institutions with different fragmented agendas, and without teachers' participation, they often fail to achieve the intended result. The researcher believes that CPD for mathematics teachers must have an owner from the mathematics department who assesses deficiencies and reports for training on these shortcomings.

4.4.10 Summary of Research Question Four

The following conclusion can be drawn based on the data analysis and discussion above. Teacher interviews and document analysis revealed that the current CPD program has some deficiencies besides its positive characteristics.

The ownership of the CPD program is unknown. The school prepares CPD and trains; some come from the Wereda education bureau, others are from the sub-city education bureau, and universities provide CPD. The problem is that there is no integration among these CPD providers. Teachers confuse its objectives and intended outcomes. The CPD program on how to use technology in teaching was impressive. Most of them were provided by higher institutions. The problem is that the schools do not have the resources to implement what the teachers are trained to teach and help their learners understand mathematics.

Connection-making is critical to help teachers during the CPD training. CPD programs that do not engage teachers in conceptual thinking and instead approach mathematics as a list of rules to remember are not engaging in the critical process of internalization (compression), so their brain is unable to organize and file away ideas; instead, it struggles to hold onto long lists of methods and rules as mathematics is a long (one concept is constructed upon previous concept) subject.

Teachers give some recommendations on preparing effective CPD. There should be collaborative work between teachers and learners following that between teachers and CPD experts, especially in integrating indigenous mathematics knowledge and considering the school context in preparing CPD. A CPD program imposed by ignoring teachers' contributions is unsuccessful.

4.5 Conclusion of the chapter

To determine the extent to which mathematics teachers' professional development equips teachers with the skill of creative teaching, teacher interviews, lesson observation, and document analysis were conducted. Wood's four features of creative teaching and Cremin's three dimensions of creative practice were used to analyse the data. The impact of teachers' conceptions and the textbook tasks are also observed in the teachers' practice during the observation session. There was no observable difference in the observed teachers' teaching skills. According to Wood (1990), teaching must be relevant to teachers and learners. This could be made by connecting school mathematics to the lives of learners, but the observed teachers teach what is written in the textbook without any adjustment.

The CPD was expected to adjust the above-described problems. The teachers' interview results showed that the CPD they took was not practicable. It lacks consideration of the school contexts and practicability of classroom training. To alleviate these deficiencies, teachers recommend that CPD be prepared in collaboration with teachers and integrate indigenous mathematics knowledge of the society.

Chapter 5: Summary, Conclusions, and Recommendation of the Study

5.0 Introduction

The goal of this chapter is to summarise the key findings of the study, which examined the extent to which CPD equips mathematics teachers with the skill of creative teaching. This chapter provides an overview of the study based on the problem statement, literature review, methodology, findings, and discussion. It is believed that the study's findings may aid in improving Ethiopian secondary schools' mathematics curricula, CPD, and teaching methods. Additionally, teachers' methods are desired to change from the usual teaching perspective to more challenging, unusual, and creative practices where the learners must be recognised as co-participants.

The key findings of the four research questions listed below are presented. The recommendations and conclusion are offered later, respectively.

1. What are mathematics teachers' perceptions of creative teaching of mathematics?
2. How do the official textbook and suggested teaching materials used in teaching mathematics relate to teachers’ and learners’ real-life contexts?
3. To what extent do mathematics teachers apply creative teaching practices in their classrooms?
4. What is the role of the existing CPD in equipping mathematics teachers with the skill of creative teaching?

5.1 Summary of the Findings of this Study

A summary of the results from the study is presented under the four research questions that guided the study.

5.1.1 Research Question 1

What are mathematics teachers' perceptions of creative teaching of mathematics?

Teachers' instruction method is affected by their perception of the concept of teaching (Jiang et al., 2023). They may think teaching tells learners something, and learning occurs if they remember it. However, teaching is not about pouring information into learners' brains and expecting them to process and apply it correctly later. The perception of secondary school mathematics teachers concerning creative teaching is presented below.

5.1.1.1 Perception and Importance of real-life Experience in Teaching Mathematics

Making connections is a process the teacher and learners learn together, involving the arguably subtler skills of intuition, intimacy, and challenge (Cremin & Chappell, 2021), leading to creativity. The study revealed that teachers tried connecting textbook mathematics to out-of-school experiences, and they found it helpful. Only teacher G1 blames the textbook as unsupportive in making connections; however, in the ICT era, this idea is unacceptable because teachers can find relevant examples online. The role of the teachers would be to contextualise them to their learners' authentic lives. The other teachers list some relevant mathematical concepts they integrated into school mathematics, including shapes in geometry and measurement, marketplace mathematics to teach fractions (see 4.1.1, teacher P2 response), and the traditional game 'shikut' in teaching probability (see 2.3.2.4, II, under games entertainment and market place mathematics for the rules of the game). Previous studies supporting this finding indicate that teachers promoted learners' instructional engagement by connecting mathematical knowledge to their learners' cultural and linguistic backgrounds (Abdulrahim & Orosco, 2020). Unfortunately, these teachers' qualities were not observed during the lesson observation session. They told what they did not do in their classroom teaching but what they think is good if these experiences are included.

5.1.1.2 Word problems are open problems

Opening up closed problems helps make the classroom more active because learners can develop several correct techniques and answers and improve their creativity skills (Ibrahim & Widodod, 2020). However, all teachers do not try to open up closed problems. Almost every closed problem could be opened (see 4.1.2, last paragraph). Some say the time provided is insufficient (Teacher G2). The researcher believes teachers could minimise solving repetitive problems for learners and include open questions to save time. Teachers P1 and N1 consider the word problems in the textbook as open tasks, but these two (similarly teachers G1, P2, & N2) do not try to design open-ended questions by themselves because they are not exposed to such kind of teaching during their pre-service and in-service training.

5.1.1.3 Solving repetitive problems helps learners understand a topic

The participant teachers responded that they added some tasks not written in the textbook, but these tasks are repetitive (see Table 4.3). They ask similar and procedural questions without posing slightly different from what they teach their learners. Learners do not learn much from repetitive questions; they can only capture the basic procedures to be followed, not the concepts. The teachers need to provide additional exercises not solved by only remembering the formulas and procedures but also by their reasoning skills (Sawyer, 2019).

5.1.1.4 Time constraint to show alternative techniques of solving a single problem.

Teachers show their learners alternative techniques for solving problems written in the textbook (see Table 4.4). They do not show additional techniques not described in the textbook, which may be found by searching other sources (such as websites, reference books, or other local methods). An alternative method of viewing and solving a single problem motivates learners to search for optimal solution methods other than what they have learned (Putri et al., 2023; Yanti et al., 2023). The researcher believes that teaching what is written in the textbook might have a message to learners; there is no way to approach the given problem other than provided by the textbook. Therefore, the role of teachers should be beyond repeating what is prescribed in the textbook by minimising repetitive procedures to save time.

5.1.2 Research Question 2

How do the official textbook and suggested teaching materials used in teaching mathematics relate to teachers' and learners' real-life contexts?

The textbook influences the teacher's teaching methods (Rezat, Fan, & Pepin, 2021). That is why teacher G1 responds that the textbook does not support making connections previously under the title connection making. Therefore, it was necessary to analyse the content and tasks of the material to see if it is helpful for creative teaching.

5.1.2.1 Connection-making trend in the textbook

The textbook does not include indigenous mathematics knowledge or real-life mathematics experiences. Ethiopian society is rich in mathematics knowledge (see 2.3.2.4), and studies conducted by Tesfamicael, Nakken, Tumebo, and Gray (2021) confirm that rich mathematical activities exist in the country. The textbook should include indigenous knowledge of the society as much as possible. Shikut is an indigenous probability game that helps to teach probability, as teacher G1 said (see 4.1.1). Including such knowledge encourages teachers to use their imagination to make connections beyond what the textbook included and helps learners find mathematics's relevance to their lives (Fries et al., 2021). Word problems are a means to make connections. However, the word problems in the grade nine mathematics textbook are designed in an unrealistic context (see 4.2.1). Therefore, teachers and learners solve the problems by ignoring the fundamental assumptions. The classroom environment created by the textbook is passive since there is no reality; learners cannot challenge the teacher, defend their solution methods, and convince each other logically. However, the textbook tasks are repetitive, procedural, and designed with an unrealistic context (see 4.2.1).

In addition**,** the chapters of the textbook are not arranged in a way to make connections between them (see 4.2.1, under pedagogy). This finding agrees with Peterson et al. (2021), who conclude that textbook authors give little attention to the logical order of topics. Therefore, teachers teach fragmented, unrealistic, and shallow knowledge even though mathematics is a connected subject (see 4.1.5, around Fig 4.1), which shows how the whole textbook could be connected.

5.1.2.2 The nature of the textbook tasks

In the textbook, no tasks are designed by combining previous concepts. Every problem is solved by applying the current concepts, not previous ideas. Therefore, they are not supportive of creative teaching, as creative teaching results from combining several ideas (Rosyadi et al., 2022). In solving such problems, teachers think of themselves as being creative.

Introducing problems: The textbook does not provide introducing and framing problems. The questioning stance of the textbook helps teachers design the instruction in response to learners' previous conceptions of the topic. Unfortunately, the textbook begins by revising the previous topic, defining the new topic, providing formulas and procedures, and solving problems. The questions come after learners are told how to think this trend is not helpful for creative teaching.

Relevant problems: The textbook problems must be relevant to the lives of teachers and learners (Alim, Hermita, Alim & Wijaya, 2021). However, the tasks provided are far from reality, forcing teachers and learners to think mathematics is an abstract subject to understand without any relevance. For instance (see the tasks under 4.2.1). The textbook is staffed with procedures to be followed and memorised, predetermined equations, and closed and repetitive problems, which are unsupportive in creating the desired classroom environment.

Open problems: The tasks in the textbook are closed and predetermined. Almost all the textbook questions are closed, and teachers do not try to open them; instead, they teach them as they are. The classroom ethos created with the textbook tasks is passive as it indicates the steps to be followed (strategies) in solving problems (see 4.2.2, under the classroom ethos). As a result, the classroom becomes teacher-centred as learners are not allowed to think for themselves to come up with different solutions and defend and justify their methods. This trend affects teachers' teaching and learners' ability to think, guess, explore, and create (Cai & Hwang, 2023).

Drawing problems: Many word problems in the textbook need drawing to visualize and understand. Even the textbook authors should not draw all to let teachers and learners draw themselves; there must be sample drawings. However, the only word problem translated to drawing in the textbook is (see 4.2.2, Q.15), even though many questions become clear by drawing (see 4.2.2, Q14). Drawing a problem helps to visualize, understand, and solve the problem (Vale & Barbosa, 2023). Lesson observation also confirms that this textbook trend was reflected in the observed teachers teaching.

5.1.2.3 The textbook does not foster the autonomy of teachers

The teaching materials took the ownership of knowledge from the teachers. There are exercises in the textbook, but their solution is available in the teachers' guide; therefore, the role of the teacher is to transmit the knowledge written by others. Hence, teachers are not considered owners of the knowledge that they teach. In addition, AI, like Chat Gpt, Bing Chat, and others, also takes ownership of knowledge.

5.1.3 Research Question 3

To what extent do mathematics teachers apply creative teaching practices in their classrooms?

The perception of teachers and the nature of the textbook have been evaluated, and then, it is necessary to identify teachers' practice in teaching the textbook's content in their natural classroom setting.

5.1.3.1 Personal quality

Solving repetitive problems: All the observed teachers are honest in helping their learners understanding. This characteristic of teachers is observed when they solve many questions for their learners. The problem is the method they follow to support their learners. The teachers solve repetitive problems and recommend their learners follow the procedures step by step to help their understanding. For instance, teacher N1 recommends that learners memorise the seven steps in solving quadratic equations using factorisation methods and shows three steps in completing the square methods (see 4.3.2 teacher N1 lesson observation). This finding aligns with Cardino and Cruz (2020, p. 23): 'Repetition is a simple tool that makes it easier for learners to master concepts without wasting time.' However, the researcher believes learners do not learn more by solving repetitive problems other than capturing the procedures to be followed.

Rash to solve problems: The other one is the teachers' rashness in answering the exercise even though they should wait until their learners solve or struggle. Learners learn much from struggle and failure. The feedback they give to their learners' solutions is also not informative; they say 'right' or 'wrong' instead of working on the learners' reasoning (see 4.3.2, teacher P2's lesson observation).

Handling learners systematically: The positive personal quality of teachers observed was the systematic way of minimising latecomers (see 4.3.2, teacher N1 lesson observation), giving learners a question, and letting them solve it to use their break or lunch early (see 4.3.2, teacher P2's lesson observation) motivates learners to collaborate in solving the problem.

5.1.3.2 Pedagogy

Theoretically, teachers have a good conception of creative teaching; they say creative teaching is a technique that helps learners' understandings and owns transferable knowledge (teachers G1 & N2); it is a concept teaching (teachers G2 & P2). Teachers also said they practice some of Wood's features of creative teaching, especially on connection-making, but it was not seen in their real classroom teaching practice during the observation session. The teaching method followed by the three teachers was similar and teacher-centred. The teachers do not make a connection between school and out-of-school mathematics. Without connection-making, neither learners nor teachers can see its relevance (Gebremichael, 2019). That means they are teaching the mathematics of the textbook's authors and are not owners of the knowledge. Teachers act like knowledge-transmitting machines and cannot apply it flexibly; therefore, teaching has no control and innovation (see 4.3.2).

5.1.3.3 Classroom ethos

The classroom arrangement in the three schools is similar; learners share a single desk for three. The number of learners per class is large, with about 55 learners on average. It is not easy to manage such a classroom on the teachers' side. In addition, the classrooms do not have teaching and learning resources other than chalk and blackboard. Teachers do not have enough teaching aids, and learners do not have a choice of learning, negatively impacting teachers' creative teaching skills and learners' learning.

Generally, the in-service teachers' interview and lesson observation data revealed that they do not fully understand mathematics; this is because all observed teachers rashly calculate numbers by ignoring the aim and objectives of the topic. The teachers seem to consider mathematics as the study of numbers, even though today's branches of mathematics have nothing to do with numbers other than as a means of communication. This perception of teachers is reflected in their teaching practice. Teachers teach their learners abstract numbers by ignoring the wisdom behind the numbers. Correcting such kind of understanding in these teachers is the role of CPD.

5.1.4 Research Question 4

What is the role of the existing CPD in equipping mathematics teachers with the skill of creative teaching?

The findings on teachers' perceptions of creative teaching, the nature of the textbook, and the teachers' practice in their actual classroom have been presented. Now, it is to discuss the findings concerning the impact of CPD on teachers' perception, practice, view towards the textbook content and tasks, and teachers' perception of the CPD.

5.1.4.1 Teachers' Perception of CPD

Teachers believe that CPD must be practicable and equip them to deal with mathematics and instructional technology changes. The CPD must help teachers to own the skill of self-evaluation and improve their teaching techniques continually (See 4.4.7). In preparing CPD for creative teaching, experts need to conduct research in school and outside of the school compound before preparing their training. They must consider the class size, school resources, and indigenous or out-of-school mathematics knowledge, and teachers must also be involved in the preparation as they are the most influential variable in the teaching process.

5.1.4.2 Teachers' Experience with CPD

The CPD did not help teachers with specific, practicable, creative teaching techniques. Teachers did not train in connection-making (to see the relevance of mathematics), adjusting unrealistic mathematical tasks in the textbooks (ownership), opening up closed problems (control), or showing alternative techniques for solving single problems (innovation), which are features of creative teaching (see 4.4.5). Most teachers believe that the CPD given in their school's main objective looks like for report writing of the school admins. For instance, the CPD does not have an owner; some come from Addis Ababa city admiration, others from the sub-city education bureau, and higher institutions provide CPD. This finding is in line with Desimone and Garet (2015), who said that it is difficult to achieve coherence when there is a multiplicity of CPD providers. All these are designed without the teachers' participation and desire, so teachers trained the CPD providers' agenda.

5.1.4.3 Challenges of participating and practicing CPD

The teachers' interview results revealed that the CPD given in their schools was not practicable for three reasons (See 4.4.5 & 4.4.6). The first one is that the CPD focus was on general teaching methods, such as learner-centred instruction methods, which are not presented systematically in a way that could easily be changed into classroom practice. The second one is that some teachers do not want to participate in CPD and change their teaching style because their expectations clash with reality, i.e., they expect more and experience little importance from CPD training. The third reason was that schools do not have resources, especially for teaching using technology (see 4.4 6).

5.2 Contribution of the Study

The study's contribution to knowledge is highlighted in this section. The research aligns with current arguments on effective teaching strategies that rely on in-depth learning techniques. In support of the technological and economic development of the nation, there is a persistent push for teaching and learning to be made more pertinent, fruitful, and driven by national goals and challenges.

The study is based on Wood's four features of creative teaching, which begins with the assumption that teaching must be relevant. Relevant teaching starts with connection-making between the school and the out-of-school experience of learners. That is, teaching needs to be constructed on what learners know before. Therefore, the study contributes to the field of mathematics education, mathematics teachers, textbook authors, and professional development experts.

5.2.1 The field of mathematics education

The impact of the ICT revolution on teaching is not addressed in mathematics education in this research perspective. This study contributes to the field of mathematics education by identifying the role of teachers in the ICT revolution era (see 1.3). This study paves the way for systematic and creative debate among mathematics educators about the role of mathematics teachers in helping their learners more than the web and AI (like Chat GPT, Bing Chat) could feed them.

5.2.2 Teachers of Mathematics

The important contribution of the study concerning mathematics teachers is that the third-millennium teaching requirement is not the same as before. Teachers need to know that pouring learners' minds with information from the textbook does not make sense today. The ICT and AI revolution flooded learners with more information and solutions to the assignments than teachers could do. Therefore, teachers need to know their role in helping their learners learn as third-millennium teachers. This research identifies several fundamental concepts that mathematics teachers need to grasp.

- ✓ The real and updated meaning of mathematics, since its definitions were continuously changing, as described in the literature (see 2.1.2), teachers need to get updates concerning the reality of today's mathematics.
- ✓ What experience of learners can be included in teaching secondary school mathematics? Learners need to get the relevance of mathematics to their lives to have a deep understanding of the concept; otherwise, they think mathematics is an abstract subject that has no relevance to their lives.
- ✓ Open-up closed problems help learners develop different brain paths (divergent thinking).
- ✓ Apply alternative techniques of solving a single problem to motivate creativity.
- ✓ Adjust unrealistic tasks to their context and draw complex problems to visualise, understand and solve.

5.2.3 Textbook authors

Textbooks are the primary teaching resource and must be prepared meaningfully (Rezat et al., 2021). As described in the document analysis, the current secondary school textbooks are procedural, staffed with predetermined equations, and most of the word problems were constructed in a false context far from reality. This study can contribute to textbook authors by identifying its deficiencies. As discussed in the analysis, the textbook lacks some qualities to use for creative teaching. The authors must consider the following:

- ✓ The connection between the contents of the text, with other subjects, and real-life context
- ✓ The textbook needs to start new concepts by asking questions to identify learners' previous conceptions of the ideas.
- ✓ The textbook needs to provide open-ended problems frequently

- ✓ Alternative techniques for solving a single problem
- ✓ Drawing questions to visualise the problem

5.2.4 Teachers' professional development

Teachers believe and confirm that learners fear and fail in mathematics more than other subjects. These perceptions have been confirmed in the 2022/2023 Ethiopian Higher Education Entrance Certificate; the lowest national average was scored in mathematics; that national average result was 25 out of 100. There is an honest desire on the part of teachers to help their learners understanding of mathematics. They also realised that they needed further support to help their learners. This study's findings provide what aspects of teacher knowledge, textbooks, and the ICT revolution should be the focus of CPD training.

- ✓ Teachers' Perceptions of Mathematics, creative teaching, and their learners
- ✓ Adjusting the relevance of the textbook content and task
- ✓ The impact of ICT and AI (like Chat Gpt) in teaching and learning and the role of teachers in this era.

5.3 Recommendation of the Study

5.3.1 Recommendations to Textbook Authors

Most of the time, teachers follow how the textbooks present the content arrangement and task designs. The current textbooks have deficiencies in their sequences of topics and designed tasks (see 4.2.1). The sequence of the textbook content needs to be arranged based on their connections. When this is done, the way from one chapter to the other will be smooth, and teachers and learners will see the continuation of one topic to the other, which is usually the result of expansion or inverse operation. Here, understanding the first topic is a foundation for the next topic. Therefore, both teachers and learners will compress the concepts, retain them, and will have a deep understanding of the ideas.

Concerning the textbook tasks, most of the textbook questions are designed in an unrealistic context, closed, and predetermined. Woods recommends that the mathematical tasks be relevant to teachers' and learners' lives. They should be authentically derived from real data, and the role of both teachers and learners should be in modelling situations based on these real data. However, every problem could not be modelled; in this situation, Woods recommends opening closed problems (control) so teachers and learners can develop several ways and answers.

Some problems are also reasonably closed with a single correct solution; the textbook needs to show alternative techniques (innovation) for solving the problem. Some textbook tasks need to be difficult; this helps learners not to be proud of easy success working on easy questions. When the tasks are difficult to solve, the textbook must draw some of the problems (Ownership) to help teachers and learners visualise, solve, and develop the skill of solving questions. Therefore, textbook authors need to prepare the book in line with Woods's four features of creative teaching.

5.3.2 Recommendations for practising teachers

Teachers need to re-invent themselves with mathematical development; creativity in the world of mathematics changes mathematics' definition several times, hence teaching mathematics. The ICT revolution makes this information available to those concerned with their teaching. Therefore, teachers must search recent publications on mathematics and teaching mathematics.

Second, teachers should start every new topic by asking questions. Teachers ' questioning stance helps them identify learners' previous understanding of the topic and construct their teaching. Here, teachers should not be rash in answering the questions; even those raised by learners should be forwarded to the classroom. The teacher must provide enough time for learners to struggle and solve problems.

Third, teachers should connect school mathematics to the real-life experience of learners. When this is done, learners understand that mathematics is a relevant subject derived from their lives and is not abstract. Relevance of the subject motivates learners to learn to themselves, not to the test or the teacher, and creativity will be cultivated in such a relaxed and relevant environment.

The fourth is in creativity teaching classroom teachers must prepare difficult tasks for their learners when the questions are solved by the direct method that the teacher lectures; this evaluates what the learners capture from the teacher, not their understanding. The tasks should be designed with slight adjustments from what learners have learned. Such kinds of tasks evaluate the learner's understanding of the topic. Otherwise, they may be proud of their easy success in solving trivial problems.

The fourth one is that teachers must provide informative feedback for learners' responses to teachers' questions. In the teacher observation session, the researcher observed that teachers responded by saying 'right' or 'wrong' for learners' answers. Such kinds of feedback do not help learners' understanding and creativity. The teacher must focus on learners' reasoning methods other than the last answer.

5.3.3 Recommendation for CPD Providers and Experts

The CPD experts must work in tangible, concrete, and practicable training. Professional development content and tasks should be tied to instructional practices (Eun, 2019). CPD programs should engage teachers in conceptual thinking instead of approaching mathematics as a list of rules to remember. General pieces of training, such as the importance of active learning and action research, are not influential in teachers teaching. Teachers need practicable activities linked to their teaching, like how to make the classroom active. Woods' four features of creative teaching help prepare practical CPD training. In addition, the experts need to study the school setting, resources, and teachers most concerned. They also need to prepare subject-specific CPD materials.

5.3.4 Recommended CPD for Creative Teaching

Based on the study findings in teachers' perceptions and practice, textbook content and task, and CPD documents, the CPD for creative teaching has more to work on. In doing so, the CPD should be grounded on Woods's four features of creative teaching in terms of Cremin's three dimensions of creative practice.

The beginning of CPD must be adjusting teachers' perceptions regarding mathematics, teaching mathematics, and learners. Mathematics teachers seem to have some misconceptions regarding mathematics. They think mathematics is the science of numbers, and number execution is the value paid to understand mathematics. This perception was observed during the lesson observation sessions in that teachers rushed to the execution of the number by ignoring the aims and objectives of the lesson. This behaviour results from what they learn as learners in traditional classrooms and teach the way they were taught before.

The second one is that the CPD should work on teachers' perceptions regarding learners' mistakes. Teachers believe that learners who learn well answer teachers' questions correctly, but the reverse may be true. For instance, if a teacher teaches 3+4=7 and asks learners 3+4=? The learners who answer correctly may catch what the teacher says, and those who make mistakes learn better if the teacher provides them informative feedback than those who respond correctly. Regarding the importance of mistakes, psychologists found that the brain's electrical activity increases when the brain experiences a conflict between a correct answer and a mistake, and our brain pays conscious attention to the mistakes (Kirschner et al., 2021; Moser et al., 2011).

Third, the textbooks are staffed with predetermined, unrealistic, and closed problems. CPD providers should adjust these shortcomings in line with Woods's four features of creative teaching. These are connection-making among topics (expansion and inverse operation), subjects, and out-of-school experience; opening up closed problems, drawing difficult tasks, and showing alternative techniques. This method makes teaching and learning enjoyable.

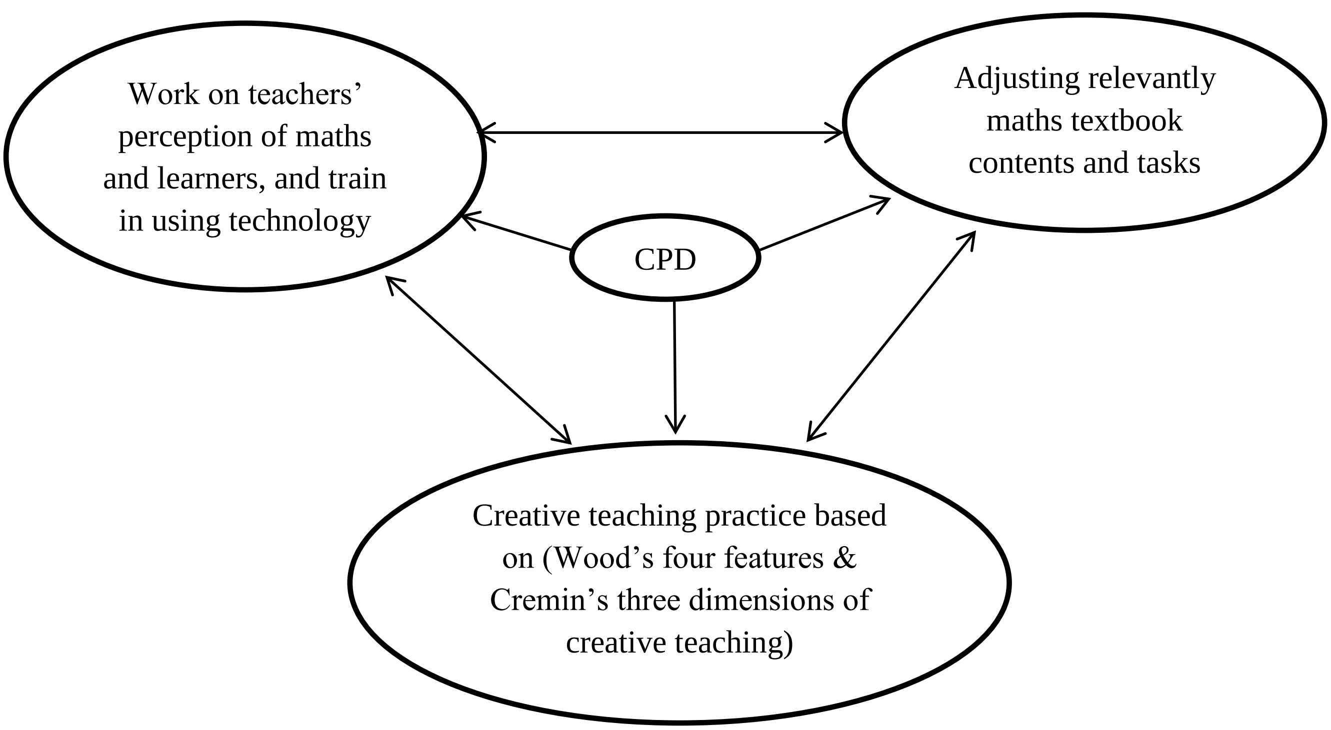


Figure 5. 1: Recommended CPD activities for creative teaching.

The third one is that the classroom practice needs to be grounded on Woods's four features of creative teaching and Cremin's three dimensions of creative teaching. Teachers must be trained in connection-making between school and out-of-school mathematics, opening up closed problems, drawing problems to visualise and solve them, and providing alternative techniques for solving a single problem. In addition, the teacher's personal qualities, the characteristics of creative teachers; pedagogy, what methods of instruction need to be applied; and classroom ethos, what should look like creativity cultivating classrooms' emotional and physical environment, should be considered in the designing of CPD, especially for creative teaching. In addition, teachers lack technological competency. CPD experts need to consider this also.

5.4 Implication for further research

The focus of the study was that giving information (Traditional method of instruction) to learners should not be the teaching concern as ICT devices could provide more information than the teacher could. Another artificial intelligence (AI) has been discovered, which provides solutions for the assignments given to learners by analysing billions of documents on the web in a few seconds. Teachers also may not want to waste their time using their brains to solve some problems and instead choose to use this AI (Chat Gpt, Bing Chat). Future studies could be done on tackling such challenges in teaching and learning mathematics to bring back the ownership of knowledge to teachers and learners.

The study was supposed to be done in rural areas of South Eastern Tigray Secondary Schools to collect indigenous mathematics knowledge. However, this was not done due to the unforeseen war between Ethiopia's federal government and Tigray's regional government. Therefore, further studies could be done to collect indigenous mathematics knowledge in rural areas.

This study was more general, in which mathematical patterns may need connection-making, open problems, drawing tasks, or showing alternative techniques are not matched. For further research, researchers can apply Wood's four features of creative teaching for specific patterns. For example, patterns of shape (measurement and geometry) could need a drawing (ownership) to visualise, understand and solve; patterns of counting may need alternative techniques (innovation) in dealing with them; patterns of motion and change need to have relevance to the learner's living environment. Matching these specific features and patterns in CPD training helps teachers practice in their classrooms.

The focus of this study was to investigate whether the existing CPD program equips teachers with the skill of creative teaching. Further research is needed on the intervention and impact of Woods's features of creative teaching in terms of Cremin's dimensions of creative teaching on teachers' teaching and learners' understanding of mathematics concepts. In addition, this study's focus was to help teachers with the skill of creative teaching. Future studies need to address creative learning techniques by putting what should be the focus learners during their learning, how learners become owners of creative knowledge and learn best at the centre of the study, if possible, in combination with neurologists to identify and design mathematical tasks that help to grow the brain.

5.5 Limitations of the Study

There could be various limiting factors that might affect the findings of the study. This study was conducted in Addis Ababa's three secondary schools. The number of sample schools was small to generalise to Ethiopian secondary schools. In addition, what looks like schooling in boarding schools, STEM schools run by universities, and schools in remote areas of Ethiopia was not addressed. Of course, most of the boarding schools are selective; the learners are selected based on their score in grade eight ministry results, and the teachers are also selected and relatively well paid. Hence, the finding may be difficult to generalise to all Ethiopian schools.

The characteristic of teachers is another possibility of bias in the interpretation of the findings. The teachers' response to the interview questions was far from reality; they responded to what they thought was the best response, which did not reflect in their classroom practice (see 4.1.1), which was not seen during the lesson observation. Triangulation was conducted to fix this problem. The observation instrument makes clear the reality in teachers' practice. The researcher, a teacher in the profession with good experience in teaching and strictly following the methodological design, helps minimise these described problems.

The study was conceptualised to be done in Tigray secondary schools to assess the indigenous mathematics knowledge of the society and integrate it into school mathematics through professional development. Unfortunately, due to the unforeseen war (conflict) between the

Ethiopian federal government and the regional government of Tigray, it was conducted in Addis Ababa secondary schools. This study was done in urban areas (Addis Ababa); future studies could be done in rural areas to collect the indigenous mathematics knowledge of the society and integrate it into school mathematics through CPD.

5.6 Conclusions

This transcendental phenomenological study unfolds the extent to which continuous professional development helps mathematics teachers equip teachers with creative teaching skills. The study focused on teachers' perceptions and teaching practice, the nature of the textbooks, syllabus, lesson plan, and CPD resources. Teacher interviews, lesson observation, and document analysis were the main tools employed to collect data.

Based on the findings of this study, several conclusions can be reached. Using Woods's four features of creative Teaching and Cremin's three dimensions of creative practice can enhance mathematics teachers' professional development for creative teaching. However, professional development experts and mathematics teachers are not aware of it. The study findings are useful for the field of mathematics education, CPD experts, in-service teachers' professional development, textbook authors, learners learning, and the teaching profession.

This study concludes that creativity is the key tool of third-millennium requirements. Both teachers and learners spent most of their active time in school. This place is where their skill of creativity could be nurtured and cultivated. Teachers are the most influential variable among other school variables in learners' competency. Therefore, they should own the skill of creative teaching.

According to this study, the beginning of creative teaching is the topic's relevance to both teachers and learners. If they cannot get the relevance of mathematics to their lives, as every concept of mathematics cannot be connected to reality, teachers should consider opening up closed problems to help learners explore the idea and come up with different brain paths. Still, some mathematical tasks are reasonably closed, and the creative teacher must show alternative techniques for solving single problems to encourage creativity. When mathematical tasks are difficult, drawing the problem to visualize helps us understand and solve it, especially when using technology. However, these are all missed in mathematics teachers' classrooms. Hence, learners consider it an abstract subject to understand. They focus on memorising the formulas and procedures rather than deeply understanding the concepts behind these methods and techniques.

Therefore, knowledge gained from this study can be applied to creative mathematics teaching, pre-service and in-service mathematics teachers' professional development, and textbook authors. Generally, Professional development training focused on creative teaching should consider Woods's four features of creative teaching in terms of Cremin's three dimensions of creative practice, which serve as a theoretical framework in this study.

5.7 Final word

This study's main objective was to determine the extent to which continuous professional development equips mathematics teachers with the skill of creative teaching.

In line with the study focus, the study's first objective was to identify teachers' perceptions of creative mathematics teaching. Using Woods's four features of creative teaching as a lens, the perception of teachers was identified. The data collection was achieved mainly through teacher one-on-one interviews.

Secondly**,** the study determines the extent to which official textbooks and suggested teaching materials teachers use in teaching mathematics help teach mathematics creatively. The textbook was analysed to determine if it is helpful for teachers to teach creatively. In this objective, the study examined using Wood's four features of creative teaching in terms of Cremin's dimensions of creative practice as a lens. Document analysis and interviews were the main instruments used to obtain this understanding.

The study's third goal was to analyse the creative teaching practice of secondary school mathematics teachers. The motive of this objective was to describe what was going on in the actual classrooms. Data was collected through the instrument lesson observation.

The fourth and final objective involved identifying the role of CPD in equipping teachers with the skill of creative teaching. The relevance of CPD and practicability were compared to Wood's four creative teaching features and Cremin's creative teaching dimension. Teacher interviews and CPD document analysis achieved this step.

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LIST OF APPENDICES

Appendix A: Supposed relevant problems

For instance, let us see the following two sample questions from the Ethiopian grade nine mathematics textbooks:

1. A mobile phone technician uses the linear function $c(t) = 2t + 15$ to determine the cost of repair, where t is the time in hours and $c(t)$ is the cost in Birr. How much will you pay if it takes him 3 hours to repair your mobile?
2. Suppose you write the days of the week on identical pieces of paper. You mix them in a bowl and select one at a time. What is the probability that the day you select will have the letter r in it?

These questions are from grade nine Ethiopian mathematics textbooks to be solved by students. But they do not make sense in real life. Every student knows that the cost of repair depends on the type of phone and the cost of the accessory to be replaced. There is no relevance in counting the number of 'r's in days of a week except for wasting time and resources. Teachers and students who are asked to solve such problems perceive that mathematics is abstract to understand and irrelevant to their lives.

Appendix B: Alternative Techniques of Solving a Single Problem

In solving quadratic equations, we can use several techniques say:

$3x^2 - 6x - 9 = 0$ ………… (*) We can apply several alternative techniques in solving this equation as discussed below.

1. Using the quadratic formula, $= \frac{6 \pm \sqrt{(-6)^2 - 4(3*-9)}}{2*3}$, is the method that we get in the textbook. Solving this, we get the value of $x = 3, -1$. This method of solution keeps students from looking at other options.

2. Simplifying (*), we get $x^2 - 2x - 3 = 0$ the students know that the value of 'x' in

   $3x^2 - 6x - 9 = 0$ is equivalent with $x^2 - 2x - 3 = (x-3)(x+1) = 0$, and we get

   the solution $x = 3, -1$ or

3. $\left.\begin{matrix} x * y = -27 \\ x + y = 6 \end{matrix}\right\}$ solving simultaneously, we get

   $9\ and\ -3, know\ we\ divide\ by\ coefficent\ of\ higher\ order\ \ x = \frac{9}{3} = 3, and\ y = \frac{-3}{3} = -1$

4. The Other option is $x^2 - 2x - 3 = 0\ implies\ x^2 - 2x = 3$ to make it a perfect square, add to both sides 1 we get $x^2 - 2x + 1 = 4$ This means $(x-1)^2 = 4$

   $x - 1 = \pm\sqrt{4}$, gives $x = 3, -1$

Appendix C: Geometric proof of Pythagoras' theorem by drawing

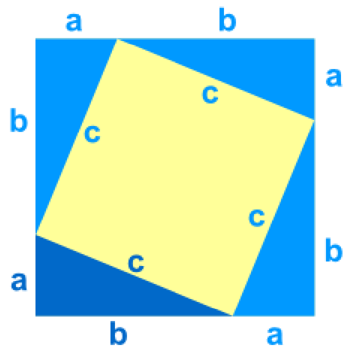

Fig 2.4: proving Pythagoras' theorem by drawing

A geometric proof of the Pythagorean Theorem relates the areas of the big square = the areas of the four blue triangles + the area of the yellow square. $(a+b)^2 = 4\left(\frac{1}{2}ab\right) + c^2$, which gives $a^2 + b^2 = c^2$

Appendix D: Ethical Clearance Certificate from UNISA

UNISA university of south africa

UNISA COLLEGE OF EDUCATION ETHICS REVIEW COMMITTEE

Date: 2020/05/13

Ref: **2020/05/13/64087298/02/AM**
Name: Mr AS Al Amin
Student No.: 64087298

Dear Mr AS Al Amin

Decision: Ethics Approval from 2020/05/13 to 2025/05/13

Researcher(s): Name: Mr AS Al Amin
E-mail address: anwalamin@gmail.com
Telephone: +251914833618

Supervisor(s): Name: Prof Mapula Ngoepe
E-mail address: ngoepmg@unisa.ac.za
Telephone: -

Name: Prof Judah Makonye
E-mail address: pjmakonye@gmail.com
Telephone: +27786894572

Title of research:

Enhancing mathematics teachers professional development for creative teaching in Addis Ababa secondary schools

Qualification: PhD Mathematics Education

Thank you for the application for research ethics clearance by the UNISA College of Education Ethics Review Committee for the above mentioned research. Ethics approval is granted for the period 2020/05/13 to 2025/05/13.

*The **low risk** application was reviewed by the Ethics Review Committee on 2020/05/13 in compliance with the UNISA Policy on Research Ethics and the Standard Operating Procedure on Research Ethics Risk Assessment.*

The proposed research may now commence with the provisions that:

1. The researcher will ensure that the research project adheres to the relevant guidelines set out in the Unisa Covid-19 position statement on research ethics attached.

University of South Africa
Preller Street, Muckleneuk Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa
Telephone: +27 12 429 3111 Facsimile: +27 12 429 4150
www.unisa.ac.za

2. The researcher(s) will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.
3. Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study should be communicated in writing to the UNISA College of Education Ethics Review Committee.
4. The researcher(s) will conduct the study according to the methods and procedures set out in the approved application.
5. Any changes that can affect the study-related risks for the research participants, particularly in terms of assurances made with regards to the protection of participants' privacy and the confidentiality of the data, should be reported to the Committee in writing.
6. The researcher will ensure that the research project adheres to any applicable national legislation, professional codes of conduct, institutional guidelines and scientific standards relevant to the specific field of study. Adherence to the following South African legislation is important, if applicable: Protection of Personal Information Act, no 4 of 2013; Children's act no 38 of 2005 and the National Health Act, no 61 of 2003.
7. Only de-identified research data may be used for secondary research purposes in future on condition that the research objectives are similar to those of the original research. Secondary use of identifiable human research data requires additional ethics clearance.
8. No field work activities may continue after the expiry date **2025/05/13**. Submission of a completed research ethics progress report will constitute an application for renewal of Ethics Research Committee approval.

Note:

The reference number **2020/05/13/64087298/02/AM** *should be clearly indicated on all forms of communication with the intended research participants, as well as with the Committee.*

Kind regards,

Prof AT Motlhabane
CHAIRPERSON: CEDU RERC
motlhat@unisa.ac.za

Prof PM Sebate
ACTING EXECUTIVE DEAN
Sebatpm@unisa.ac.za

Approved - decision template – updated 16 Feb 2017

University of South Africa
Preller Street, Muckleneuk Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa
Telephone: +27 12 429 3111 Facsimile: +27 12 429 4150
www.unisa.ac.za

Appendix E: Assistance letter from the city government of Addis Ababa Education Bureau

አዲስ አበባ ከተማ አስተዳደር
ትምህርት ቢሮ

Biiroo Barnoota Bulchinsa
Magaalaa Finfinnee

City Government of Addis Ababa Education Bureau

ቁጥር ኧ412/3589/ፖ6 20/35
Ref.No
ቀን 13/03/14
Date

ለአቃቂ ቃሊቲ ክፍለ ከተማ ትምህርት ፅ/ቤት

<u>አዲስ አበባ</u>

ጉዳዩ:- *ትብብር እንዲደረግ ስለማሳሰብ::*

ከደቡብ አፍሪካ ዩኒቨርስቲ (UNISA) በቀን November 11,2021 በቁጥር UNISA-ET/KA/ST/29/11-11-2021 በተፃፈ ደብዳቤ በDepartment of maths Education የዶክተሬት ተማሪ የሆኑት አቶ አንዋር ሰኢድ አልአሚን "Enhancing mathematics teachers professional development for creative teaching in Addis Ababa secondary schools." በሚል ርዕስ ጥናትና ምርምር ለመስራት መረጃ የሚሰበስቡ መሆኑን በመጥቀስ የጥናቱን ፋይዳ ከግምት ውስጥ በማስገባት አስፈላጊውን ትብብር እንዲደረግላቸው ጠይቀውናል::

በመሆኑም ለጥናታቸው የሚሆነውን መረጃ ለማሰባሰብ የእናንተ ክፍለ ከተማ የተመረጠ በመሆኑ አስፈላጊውን ትብብር እንድታደርጉላቸው አሳስባለሁ::

ከሰላምታ ጋር!!

ብዙነህ በቀለ በዳኔ
የመምህራን፣ትምህርት አመራርና ባለሙያዎች
ልማት አስተዳደር ዳይሬክቶሬት ዳይሬክተር ተወካይ

<u>ግልባጭ</u>

በአዲስ አበባ ከተማ አስተዳደር ትምህርት ቢሮ

- ለም/ቢሮ ኃላፊ
- ለመምህራን፣ትምህርት አመራርና ባለሙያዎች ልማት አስተዳደር ዳይሬክቶሬት

<u>ትምህርት ቢሮ</u>

አድራሻ- 6 ኪሎ አንበሳ ግቢ አጠገብ የአዲስ አበባ ትምህርት ቢሮ ህንፃ 1ኛ ፎቅ
Email:- aacaebc@gmail.com
ስልክ Tel +25111 1 22 38 99
ፋክስ Fax 223888
ፖስታ ሣ.ቁ. POBox 744,
አዲስ Addis

"ጥራት ያለው ትምህርት ለሁሉም" Barnoota Qulqullina Qabu Hundaaf

Appendix F: Tentative timetable to collect data

Date	School	Time	Teacher	Instrument
24/11/21	G, P	9:30 AM-2:30 PM		Document
25/11/21	N	9:30-11:30 AM		Document
29/11/21	G	10:30-11:30 AM 2:00-3:00 PM	G1 G2	Interview Interview
30/11/21		8:30-9:15 AM	G1	Observation
01/12/21	P	9:00-10:00 AM 2:00-3:00 PM	P1 P2	Interview Interview
03/12/21		10:00-10:45AM	P1	Observation
02/12/21	N	9:30-10:30AM 2:00-3:00PM	N1 N2	Interview Interview
06/12/21		8:30-9:15 AM	N1	Observation

Appendix G: Document analysis

Descriptions	Yes	Partially	No
Lesson objectives consider connection-making.			
Lesson objectives look for pupils' collaboration.			
Lesson objectives help to engage students in complex tasks.			
The lesson plan starts with a new topic by asking questions.			
The lesson plan connects chapters, subjects, and learners' real lives.			
Teaching aids and resources are helpful for teachers' and students' choice of learning.			

Descriptions	Yes	Partially	No
Syllabus objectives consider connection-making.			
Syllabus objectives look for pupils' collaboration.			
Syllabus objectives help to engage students in complex tasks.			
The syllabus indicates that teachers start a new topic by asking questions.			
The syllabus helps to make connections between chapters, subjects, and learners' real lives.			
Teaching aids and resources are helpful for teachers' and students' choice of learning.			

Appendix H: Interview guide

One on one Interview questions

Time of interview: ______________________ Date: ___________________________________

Place: __________________________________ Interviewer: ____________________________

Interviewee: ____________________________ Position of interviewee: ___________________

Duration of interview: ______________________ Years of experience:___________

Qualification: __________________

Part A: Teachers' Perceptions

1. What is creative teaching to you?
2. How do you help your students connect between school and real-world mathematics?
3. What teaching approaches do you apply to teach mathematical tasks/concepts that are difficult for learners?
4. Do you try to adjust some unrealistic tasks or the order of lessons that need modification in the textbook that you teach?
5. What teaching strategies do you recommend in the ICT era to make teaching meaningful?

Part B. CPD experience

1. In what time interval and for how long (duration) per year was the CPD program given?
2. What was the impact of the CPD program in helping teachers teach mathematics in an unusual (creative) way?
3. How do you see the practicability of the CPD that you took in teaching mathematics creatively?
4. What challenges do you experience in implementing the skill you get during the CPD program?
5. Would you describe what you think the ideal CPD program for creative teaching should be?
6. How do you recommend integrating our society's indigenous knowledge or real-life context of mathematics into CPD?

Appendix I: Observation Guide

School: --

Class: ------------------------- Date: ----------------------

Topic: --

A) Personal quality
1. The teacher is curious and inspires his students
2. The teacher uses his imagination to make a connection
3. The teacher is responsive to the learner's ideas and situations
4. The teacher considers their self as a creative teacher and act accordingly
B) Pedagogy
1. The teacher makes amendments when needed
2. The teacher makes a connection between school mathematics and out of school learner's experience of mathematics
3. The teacher starts the lesson by asking questions
4. The teacher uses flexible teaching styles in response to the learner's situation
C) Classroom ethos
1. The teacher shares responsibility for the learners toward their learning
2. The classroom is safe for making mistakes and collaborative work
3. The teacher provides enough time for the learners to struggle
4. The teacher respects the learner's unusual ideas

Appendix J: A letter from the language editor

Document Title: ENHANCING MATHEMATICS TEACHERS PROFESSIONAL DEVELOPMENT FOR CREATIVE TEACHING IN ADDIS ABABA SECONDARY SCHOOLS.

Author: A S AL-AMIN

Date: 9/15/23

This document certified that the above manuscript was edited by

Dr. Befekadu Lemma (PhD. English Language Teaching)

I have edited the document for proper English language, grammar, punctuation, spelling, and overall style. The editor ensured that the author's intended meaning was not altered during the review. All amendments were tracked with the Microsoft Word track changes feature. Therefore, the author could accept or reject each change individually.

Kind regards

Dr. Befikadu Lemma (cell: +251913722811)

Email: befikadu.lemma@aastu.edu.et